WEST INDIAN BULLETIN.

The Journal of the Imperial Department of Agriculture for the West Indies.

VOLUME XII.

ISSUED UNDER THE AUTHORITY

OF THE

COMMISSIONER OF AGRICULTURE

FOR THE WEST INDIES.

Barbados: Messrs. Bowen & Sons, Bridgetown.

London: Messrs. Dulau & C., 37, Soho Square, W.

1912.

CONTENTS.

WEST INDIAN AGRICULTURAL CONFERENCE, 1912.

ERRATA IN VOLUME XII.

Page 142, line 46, *for* 'monology' *read* 'terminology'.

Page 144, line 7, *for* 'in' *read* 'is'.

Page 145, for a more accurate list see p. 279.

Page 217, line 17, *for* '*Centrix*' *read* '*Centris*'.

Page 220, line 29, *for* 'oleander' *read* 'black'.

Page 221, line 10, *for* 'numbers' read 'members'.

Page 279, line 24, *for* 'suggested' *read* 'revised'.

Page 283, last line but one, *insert* 'and' *before* 'on cacao stems'.

Page 371, line 2 below diagram *for* 'Figametes' *read* 'F. 1 gametes.'

Page 409, line 28, *for* 'to the previous paper' *read* 'in the previous paper.'

Page 409, line 29, *for* '*Sclerocderris*' *read* '*Scleroderris*.'

Page 430, line 3 from bottom, *for* 'just' *read* 'first'.

Page 452, line 7 from bottom, *for* 'Oleander' *read* 'black'.

Page 453, column 1, line 12, *for* '*Cocophagus*' *read* '*Coccophagus*'.

Page 453, column 2, lines 16 and 17, *for* '*cerripediformis*' *read* '*cirripediformis*'.

Page 453, column 1, at bottom, *read instead*: '*Z. mirum* was bred from this same scale material, and *H. balloui* may be a secondary parasite'.

Page 454, line 15, *for* 'Proctrotiypidae' *read* 'Proctotrypidae'.

Page 454, line 23, *for* '*Encoila*' *read* '*Eucoila*'.

Page 456, column 1, line 7, *for* '*denterus*' *read* '*deuterus*'.

Page 456, column 1, line 2 from bottom, *for* '*bellicosis*' *read bellicosus*'.

Page 457, column 1, line 3 from bottom, *for* '*ochrodernus*' *read* '*ochroderus*'.

Page 457, column 1, last line, *for* '*Calisoma*' *read* '*Calosoma*'.

Page 457, column 2, line 2, *for* 'filies' *read* flies'.

Page 457, column 2 line 21, *for* '*Pyrformis*' *read* '*Pyriformis*'.

Page 457, column 2, line 3 from bottom, *for* 'Bermuda' *read* 'Barbuda'.

Page 458, lines 1 and 26, *for* 'oleander' *read* 'black'.

Page 459, line 21, *for* 'Zalophothirx' *read* 'Zalophothrix'.

Page 467, line 26, *for* £21 3*s*. 4*d*. *read* £21 9*s*. 8*d*.

Page 470; column 9 should read :—

Per cent. of total acid.
7·0
8·4
8·7
9·3
10·6
11·6
11·4
13·2

Page 472, column 4, *for* '19 9 10' *read* '16 9 0'

Page 481, line 16, *delete* the figure above 'in'.

Page 492, line 12 from bottom, *for* 'the end of parent hyphae' *read* 'the end of the parent hypha'.

Page 540, column 5 (upper table), *for* '9·07' *read* '·07'.

Page 546, column 6 (upper table), *for* '280·0' *read* '28·0'.

Page 547, column 6 (upper table), *for* '33·2' *read* '53·2'.

Page 561, line 14, *for* 'oleander' *read* 'black'.

WEST INDIAN BULLETIN

VOL. XII No. 1

MANURIAL EXPERIMENTS WITH COTTON IN THE LEEWARD ISLANDS.

BY H. A. TEMPANY, B. SC.,

Superintendent of Agriculture for the Leeward Islands.

Manurial experiments with cotton have again been carried out in St. Kitts, by Mr. F. R. Shephered, and in Montserrat, by Mr. W. Robson, during the year 1911. Experiments of this description were commenced in 1904-5, and have been made annually on similar lines since then. On the present occasion the series is identical with that of former years, and comprises thirty-eight experiments in St. Kitts and thirty in Montserrat.

The experiments were carried out on plots each $\frac{1}{40}$-acre, in duplicate, at La Guérite Experiment Station, St. Kitts, and on single plots at Dagenham estate, Montserrat. The manures applied, the yields obtained in each series, and the average returns from each experiment are shown in Table I.

As has been stated, the St. Kitts series included eight more plots than does that in Montserrat; these eight additional plots were designed to test whether beneficial results are likely to occur from applications of small amounts of salt and sulphate of copper to the soil, the idea being that they might possibly lessen the incidence of insect and fungoid pests. The accumulated results obtained have demonstrated by now that no such action takes place, and it is not intended to include them in the series of experiments in future years.

TABLE
MANURES AND YIELDS

No. of Experiment.	Nitrogen as nitrate of soda.	Nitrogen as sulphate of ammonia.	Potash as sulphate of potash.	Phosphoric acid as basic phosphate.	Cotton seed meal.	Salt.
1	...	...	No manure		...	...
2	...	...	Pen manure		...	...
Nitrogen Series.						
3	...	...	30	40	...	...
4	...	20	30	40	...	...
5	...	30	30	40	...	...
6	20	...	30	40	...	...
7	30	...	30	40	..	...
8	...	30	30	...	...	...
9	...	20	...	...	...	...
10	...	30	...	...	...	...
11	20	...	...	...	...	...
12	30	...	...	...	...	...
Phosphate Series.						
13	...	30	30	...	..	...
14	...	30	30	40	...	...
15	...	30	30	60	...	...
16	...	30	30	80	..	...
17	...	...	...	40	...	...
18	...	30	30	40*	...	...
19	...	30	30	60*	...	...
Potash Series.						
20	...	30	...	40	...	...
21	...	30	20	40	...	...
22	...	30	30	40	...	...
23	...	30	40	40	...	...
24	...	...	40	...	...	...
Cotton Seed Meal Series.						
25	...	...	...	...	300	...
26	...	...	...	...	600	...
27	...	...	30	...	300	...
28	..	...	...	40	300	...
29	...	...	30	40	300	..
30	...	30	30	40	300	...
Salt Series.						
31	...	...	...	...	...	100
32	...	...	...	...	...	200
33	...	30	30	40	...	100
34	...	30	30	40	...	200
35	...	...	...	...	300	100
Sulph. of Copper Series.						
36	...	...	...	...	...	...
37	...	30	30	40	...	...
38	...	...	...	...	300	...

* Phosphoric acid as superphosphate.

I.

IN POUNDS PER ACRE, 1911.

Sulphate of copper.	La Guérite. I.	La Guérite. II.	Montserrat.	Mean of all Stations.	Difference on No manure.
..	1,392	1,142	706	1,080	...
...	1,412	1,145	647	1,068	– 12
...	1,412	1,005	611	1,009	– 71
...	1,512	1,397	546	1,152	+ 72
...	1,240	1,212	528	993	– 87
...	1,720	1,317	468	1,178	+ 98
...	1,312	1,065	517	965	– 115
...	1,590	1,352	428	1,123	+ 43
...	1,220	1,080	485	928	– 152
...	1,347	1,150	334	944	– 136
...	1,480	1,027	405	971	– 109
...	1,342	1,162	355	946	– 134
...	1,590	1,352	428	1,123	+ 43
...	1,240	1,212	528	993	– 87
...	1,327	1,165	390	961	– 119
...	1,530	1,107	381	1,006	– 74
...	1,582	1,005	365	984	– 96
...	1,540	762	310	871	– 109
...	1,480	1,037	313	943	– 37
...	1,142	1,270	292	901	– 179
...	1,247	1,265	300	937	– 143
...	1,240	1,212	528	993	– 87
...	1,367	970	291	876	– 204
...	1,465	1,112	362	980	– 100
...	1,310	1,410	387	1,036	– 44
..	1,517	1,000	350	956	– 124
...	1,560	915	406	960	– 120
...	1,605	1,182	367	1,051	– 29
...	1,555	1,182	446	1,061	– 19
...	1,367	1,080	406	951	– 129
...	750	865	...	808	– 459
...	915	625	...	770	– 497
...	1,270	995	..	1,132	– 135
..	1,565	887	...	1,226	– 41
...	1,567	810	.	1,189	– 78
20	1,207	960	...	1,084	– 183
20	1,670	920	...	1,295	+ 28
20	1,515	1,065	...	1,290	+ 23

TABLE II. La Guerite. Series I and II.

Manures and yields in pounds per acre.
Mean of seven years—40 plots.

No. of Experiment.	Nitrogen as nitrate of soda.	Nitrogen as sulphate of ammonia.	Potash as sulphate of potash.	Phosphoric acid as basic phosphate.	Cotton seed meal.	Salt.	Sulphate of copper.	Seed-cotton.	Difference on No manure.
1	...	...	No manure		...	...	...	1,336	...
2	...	...	Pen manure		...	...	...	1,380	+ 44
Nitrogen Series.									
3	...	...	30	40	...	...	.	1,278	- 58
4	...	20	30	40	...	...	...	1,405	+ 69
5	...	30	30	40	...	..	...	1,290	- 46
6	20	...	30	40	..	...	...	1,422	+ 86
7	30	...	30	40	...	...	..	1,226	- 110
8	...	30	30	...	...	...	...	1,369	+ 33
9	...	20	...	...	...	...	...	1,157	- 179
10	..	30	...	...	...	...	...	1,333	- 3
11	20	...	...	...	...	...	...	1,446	+ 110
12	30	...	...	...	...	...	...	1,401	+ 65
Phosphate Series.									
13	...	30	30	...	...	...	...	1,369	+ 33
14	...	30	30	40	...	...	...	1,290	- 46
15	...	30	30	60	...	...	...	1,356	+ 20
16	...	30	30	80	..	...	...	1,405	+ 69
17	...	...	...	40	...	...	...	1,295	- 41
18	...	30	30	40*	...	...	...	1,322	- 14
19	...	30	30	60*	...	.	..	1,270	- 66
Potash Series.									
20	...	30	..	40	...	...	...	1,252	- 84
21	...	30	20	40	...	...	...	1,203	- 133
22	...	30	30	40	...	...	..	1,290	- 46
23	...	30	40	40	...	...	...	1,294	- 42
24	...	...	40	..	...	..	...	1,284	- 52
Cotton Seed Meal Series.									
25	...	...	...	...	300	.	...	1,369	+ 33
26	...	...	...	...	600	...	..	1,405	+ 69
27	...	...	30	...	300	...	...	1,373	+ 37
28	...	...	...	40	300	...	...	1,408	+ 72
29	...	...	30	40	300	...	...	1,408	+ 72
30	..	30	30	40	300	...	...	1,357	+ 21
Salt Series.									
31	...	...	...	...	...	100	...	1,098	- 238
32		...	...	...	...	200	...	1,128	- 208
33	...	30	30	40	...	100	...	1,247	- 89
34	...	30	30	40	...	200	...	1,162	- 174
35	...	...	..	..	300	100	...	1,213	- 123
Sulph. of Copper Series.									
36	...	...	...	...	...	...	20	1,182	- 154
37	...	30	30	40	...	...	20	1,218	- 128
38	...	...	...	...	300	...	20	1,228	- 118

TABLE III. ALL STATIONS.

MANURES AND YIELDS IN POUNDS PER ACRE.

Mean of seven years—40 plots.

No. of Experiment.	Nitrogen as nitrate of soda.	Nitrogen as sulphate of ammonia.	Potash as sulphate of potash.	Phosphoric acid as basic phosphate.	Cotton seed meal.	Salt.	Sulphate of copper.	Seed-cotton.	Difference on No manure.
1	...	...	No manure		...	...	...	954	...
2	...	...	Pen manure		...	...	...	991	+ 37
Nitrogen Series.									
3	..	...	30	40	...	...	...	955	+ 1
4	...	20	30	40	. .	...	...	986	+ 32
5	...	30	30	40	...	..	...	999	+ 45
6	20	...	30	40	.	...	...	973	+ 19
7	30	...	30	40	...	...	...	945	– 9
8	...	30	30	...	...	...	...	995	+ 42
9	...	20	...	...	..	...	...	898	– 56
10	...	30	...	...	..	...	...	1,004	+ 50
11	20	...	...	...	...	...	...	996	+ 42
12	30	...	...	...	...	...	...	957	+ 3
Phosphate Series.									
13	...	30	30	...	.	...	...	995	+ 41
14	...	30	30	40	...	...	...	994	+ 40
15	...	30	30	60	..	...	...	947	– 7
16	...	30	30	80	...	...	..	978	+ 24
17	...	...	...	40	...	...	..	930	– 24
18	. .	30	30	40*	...	..	...	934	– 20
19	...	30	30	60*	...	...	...	891	– 63
Potash Series.									
20	...	30	...	40	...	..	...	919	– 35
21	...	30	20	40	. .	. .	...	854	– 100
22	...	30	30	40	...	...	...	994	+ 40
23	...	30	40	40	...	..	...	901	– 53
24	...	...	40	...	...	...	...	933	– 21
Cotton Seed Meal Series.									
25	...	...	...	...	300	...	...	935	– 19
26	...	...	...	...	600	...	.	926	– 28
27	...	...	30	...	300	...	...	939	– 15
28	..	...	...	40	300	...	...	996	+ 42
29	..	...	30	40	300	...	...	936	– 18
30	...	30	30	40	300	...	...	901	– 53

* Phosphoric acid as superphosphate.

The results of the present season have borne out the general experience of former years, namely that the application of manures has not given profitable increases of yield. With the exception of plot 6, which received 30 lb. of nitrate of soda with potash and phosphoric acid, and showed a gain, over the yield from the no-manure plot, of 98 lb. of seed-cotton per acre, none of the plots show any appreciable gain as a result of the action of the manures; indeed most of them evidence actual losses.

This result, in the case of the experiments at La Guérite, St. Kitts, is somewhat unexpected; since not inconsiderable increases of yield over that from the no-manure plot were recorded from many of the plots at this station in the previous year. It will be remembered that this series of experiments has now been repeated for seven consecutive years, and in each year in each series the same manures have been applied to the same plots. Last year it was thought that the effect of this continuous cropping was at last being seen in the exhaustion of the no-manure plot, but the results of the present year do not strengthen this conclusion.

On the present occasion, only two series of experiments have been carried out, the third series having had to be sacrificed on account of requirements in connexion with railway construction for the new St. Kitts Central Sugar Factory. It will be remembered that the plants in the various series are grown at different times, Series I being the earliest, and Series III, the latest established.

The continuous repetition of these experiments, under the conditions stated above, constitutes a valuable investigation into the manurial requirements of cotton in the circumstances obtaining in St. Kitts.

Table II gives the average returns from Series I and II at La Guérite over the whole period during which the experiments have been carried on; the returns from Series III are not included, since past experience has shown that late planting induces poor returns in St. Kitts; the figures are the means of the results of fourteen repetitions of each experiment on the same piece of land, under varying conditions of rainfall. An inspection of these results will show that, with the doubtful exception of plot II, which received 20 lb. of nitrogen as nitrate of soda, the application of manures has not only failed to increase the yield but in many instances has led to actual decreases. This result strengthens the conclusions of former years, namely, that during the period of the experiments, the natural reserves of plant food in the soil have been sufficient to meet the requirements of the crop, under the conditions obtaining at La Guérite.

Table III gives the average results for the entire series of experiments, covering forty repetitions of each individual trial during a period of seven years, and including series in St. Kitts, Nevis, Montserrat and Antigua. It will be seen that, in no single instance are appreciable increases of yield traceable to the action of the manures.

The results bear out the opinion expressed in previous reports on these experiments that, under the conditions obtaining in the Leeward Islands, the best results in Sea Island cotton culture are

likely to be obtained by good cultivation combined with occasional small applications of farmyard manure for the purpose of maintaining a good mechanical condition of the soil, and that the plication of artificial manures is not likely to be remunerative.

THE COTTON INDUSTRY IN THE LEEWARD ISLANDS.

BY H. A. TEMPANY, B. Sc.,
Superintendent of Agriculture for the Leeward Islands.

In previous years, papers have been published in the *West Indian Bulletin* summarizing the development and position of the cotton industry in the Leeward Islands.

Most of these have been presented at Agricultural Conferences ; while in 1909 the position of the industry in the Leeward Islands was dealt with in an article containing an account of the state of the industry throughout the West Indies, which appeared in the *West Indian Bulletin*, Vol. X, p. 153 ; accounts of the progress of the industry in earlier years have appeared in the *West Indian Bulletin* as follows : Vol. VI, p. 113 ; Vol. VII, p. 30 ; Vol. VIII, p. 203 ; Vol. IX, p. 179.

The following additional data are now put forward, to supplement the accounts already given, and to bring the information regarding the progress of the industry up to date.

During the past few years, cotton-growing, particularly in Antigua and Barbuda, has undergone a number of vicissitudes which have at certain periods materially affected the area planted and the output. Such circumstances may normally be expected to beset any industry ; at the present time it may be said that they have exerted a steadying influence on the cultivation of cotton in the Leeward Islands, and the position is now one of considerable stability which is an important condition in the economic outlook.

In Montserrat at the present time, cotton-growing is the principal source of revenue. In Nevis, it occupies a position nearly equal to that of cane-growing. In St. Kitts the cultivation of cotton as an intervening crop between two crops of cane is an integral part of current agricultural practice, while the growing of the product as a main crop is extending. In Tortola and Anguilla it fills the position of an important staple crop raised by small cultivators, and thus supplies a source which has materially conduced to the increase of prosperity. Antigua has perhaps suffered more vicissitudes in respect of cotton-growing than any other Presidency ; but here again prospects have brightened, and there is the probability of a considerable increase in the area under cultivation.

In the following pages the position of the industry in the various presidencies is summarized.

ANTIGUA.

As has been stated already, the cultivation of cotton in this Presidency has undergone very considerable vicissitudes. The staple has had to contend with what is probably the most serious pest which has beset the industry since its inception, in the shape of the maggot of a small fly (*Contarinia gossypii*) which attacks the unopened flower buds and causes them to drop from the plant.* The pest was first recorded in December 1907; subsequent experience has shown that the general appearance of the insect may be expected annually at about the same period of the year—the middle of December; consequently, the control of the pest evolves itself into a question of planting the crop at such a time as shall ensure the maturing of the cotton bolls before its incidence may be anticipated. Unfortunately, this is not always an easy matter, since by reason of the uncertainty of the rainfall it is not always possible to establish the crop at such a time as will ensure its escaping the attacks of the pest. Nevertheless some measure of success has been obtained by working on these lines.

For the crop of 1909-10, 253 acres was planted in Antigua, while some 125 acres was also established in the dependent island of Barbuda, making a total of about 378 acres in the Presidency. From this, 59,960 ℔ of lint was obtained—an average return of 159 ℔ of lint per acre, and the best average yield per acre recorded since cotton-growing has been undertaken.

For the crop of 1910-11, 440 acres was planted in Antigua and 130 in Barbuda—a total of 570 acres. Owing to dry weather, much difficulty was experienced in establishing the crop, but the yields have, on the whole, been satisfactory; at the time of writing 275 bales, of 220 ℔. each, have been ginned in Antigua. Good returns have also been experienced in Barbuda and it seems likely that the total production of the Presidency may amount to between 80,000 and 90,000 ℔ of lint. Much of the increase in area over that planted in 1909-10 is due to trials by planters of a few acres under the crop, and there would appear to be a likelihood of a further increase for the season of 1911-12.

At the present time root disease of sugar-cane is an important controlling factor in the economic outlook of Antigua, and the fact has now obtained considerable recognition. To rid the land of this disease, it is necessary that some system of rotation should be evolved; and in this the cultivation of cotton should play an important part, since no other crop known at present possesses the advantages offered by it in freeing the land from disease, while at the same time some prospect is offered of a pecuniary return. The possibilities in this direction are receiving recognition by planters, and on this account a considerably increased importance may be expected to be attached to cotton in the future.

ST. KITTS-NEVIS.

The following account of the position of the industry in this Presidency has been forwarded by the Agricultural Superintendent, Mr. F. R. Shepherd.

*See *West Indian Bulletin*, Vol. X, p. 1.

The last review of the cotton industry, up to the year 1908-9, was published in the *West Indian Bulletin*, Vol. X, p. 162.

During the season of 1909-10, the area planted in the Presidency was reduced from 4,000 to 3,000, acres. This reduction was due in some instances to low prices obtained in the previous season, and in other cases to the small yield resulting from bad weather conditions.

The estimated area planted in each island was as follows:—

St. Kitts	1,100 acres
Nevis	1,000 ,,
Anguilla (about)	1,000 ,,
Total	3,100 acres.

In St. Kitts, the return per acre was much above those of previous years, averaging about 200 ℔. lint per acre as the output of the island; the prices obtained were excellent, ruling from 1*s*. 7*d*. to 1*s*. 10*d*. per ℔. for first quality lint, and going as high as 1*s*. 5*d*. for Stains.

In Nevis, the returns were more favourable than in the previous season, the output averaging 135. ℔. of lint per acre, and prices ranging from 1*s*. 4*d*. to 1*s*. 10½*d*. per ℔. of lint.

In Anguilla, from general unfavourable climatic conditions, the returns were very low, only averaging about 40 ℔. of lint per acre on the output of the island.

The area of cotton planted in the Presidency during the past season was about 3,800 acres, an increase of about 700 acres on the previous season's planting

The estimated area in each island was as follows:—

St. Kitts	1,500 acres
Nevis	1,300 ,,
Anguilla (estimated)	1,000 ,,
Total	3.800 acres

The exports of lint for the past crop until April 30 were as follows:—

St. Kitts	306,013 ℔.
Nevis	269,440 ,,
Anguilla	64,730 ,,

This represents the bulk of the crop. In St. Kitts the return per acre is about equal to that of the previous season; while in the case of Nevis the yield per acre is the largest yet recorded, since the inauguration of the cotton industry.

Both in St. Kitts and Nevis, the cotton during the past season has been particularly free from the attacks of pests or diseases, the cotton worm, leaf-blister mite, and cotton stainer, being conspicuous by their absence.

The general conditions of cotton-growing in the three islands are very different. In St. Kitts, the greater part of the crop is planted as an 'intervening' crop with cane, and after the first picking the trees are pulled up and buried, or burned, for the lan d

to be planted in cane. This system renders the growing of cotton cheaper, and has given excellent results both with cotton and sugar-cane.

On account of soil and climatic conditions, the cotton crop is also a reliable one in St. Kitts, there being less tendency to fungoid diseases and dropping of bolls than in Nevis.

In Nevis, the success of the previous season, and good prices, induced growers to put in a much larger area, about half of which was planted by peasants. Here, the cotton is planted as a continuous crop, and if possible, is kept for a second picking. There has been much improvement, especially among the small growers, in the cultivation and care of the cotton, and this has resulted in the receipt of very good returns. The selection of seed by the Department of Agriculture, and the sale of it to the small growers at 1*d.* per ℔., during the last three seasons, have been greatly appreciated.

On the whole, the cotton industry in Nevis at the present time is in a very satisfactory condition, and has taken to a very large extent the place of sugar production as the leading industry in the island. The cotton ginnery at Stoney Grove, and the factory known as the Nevis Ltd., now worked by a London firm, have been employed, and several ginneries have been erected in different parts of the island.

In Anguilla, with the exception of that produced by one large grower, Mr. C. Rey, the cotton is grown in very small areas by peasants; the conditions are oft n most unfavourable, owing to drought and the wind-swept s ate of the island, hence the average return per acre is not so h gh as in St Kitts or Nevis.

Mr. C. Rey, who owns a large factory for ginning, has done a great deal to keep up the life of the cotton industry in this small island. Loans are granted to him from the local Government and the British Cotton Growering Association, which enable him to advance small sums to the peasant growers while the cotton is growing. The industry has been the means of affording a living to the people of this island, and has also brought additional revenue to the Government, on account of the increased purchasing power that it gives to the population ; as before the planting of cotton, the exports were nil, while now their value is between £3,000 and £4,000.

During the season under review, manurial experiments with cotton have been continued at La Guérite in St. Kitts, on the same lines as in previous years. (See page 1 of this issue of the *West Indian Bulletin.*) Cotton selection experiments have also been continued, and a large quantity of specially selected seed grown at La Guérite was sold and distributed for planting during last season.

The following return gives the exports of cotton from the Presidency during the past three seasons:—

	October 1, 1908, to September 30, 1909; lb. lint.	October 1, 1909, to September 30, 1910; lb. lint.	October 1, 1910; to September 30, 1911; lb. lint.
St. Kitts ...	207,146	231,150	311,441
Nevis	104,160	129,963	282,078
Anguilla ...	49,320	43,400	68,530
Total ...	360,626	404,413	662,049

MONTSERRAT.

The following account has been prepared by Mr. Robson, the Curator of the Botanic Station.

The area under cotton in the season 1910-11 was estimated to be about 2,000 acres. The increase in area, over that planted for the 1909-10 crop, was almost solely on account of the extended area put in by the small growers, chiefly in the northern and northeastern districts of the island. The area cultivated by the larger cotton planters does not vary much from year to year, and the fluctuations that have occurred in the total area planted in recent years have been brought about by the varying interest shown by the small grower. In the past season, the area of cotton in the hands of cultivators of this class was probably the largest recorded up to that time.

The prolonged droughts in the month of May and June 1910 considerably impeded the establishment of the crop; this was especially the case on the windward side of the island. On the leeward side, on the other hand, weather conditions were, on the whole. distinctly favourable; and there was, all through the season, a marked absence of high winds. A point of interest is the fact that, even with the very scanty rainfall on the windward side of the island, the extensive area in the hands of Messrs. Sendall and Wade gave the largest recorded crop for those estates.

The return generally was distinctly favourable. The total yield of lint amounted to close on 380,000 lb.—the largest recorded since the inception of the industry. Picking commenced early, and more than half the crop had been gathered by the end of November. The dry weather experienced during the reaping season was particularly favourable to the crop, the cotton being picked clean and dry.

Considerable improvement has been effected on some of the larger estates in the methods of drying and cleaning cotton.

The usual pests have been more or less present. Attacks of the cotton worm were very severe, but leaf-blister mite has not done material damage. The flower-bud maggot, while it has

been reported to be present on a small area on one estate, has not occurred as a serious pest. The bacterial disease of cotton has been noticed in its several forms, as boll disease, black arm, and angular leaf spot, in most districts in the island.

Generally, the outlook for the industry is promising. As a result of the good returns obtained during the past season and the enhanced price paid to the peasants for seed-cotton, the proposal is for a considerable further increase in the area under the crop planted for 1911-12. Several hundred acres of land formerly in bush are this season being re-introduced into cultivation by the peasant growers, and it is estimated that the total increase in the area cultivated in this way will amount to between 800 and 1,000 acres.

THE VIRGIN ISLANDS.

Mr. W. C Fishlock has contributed the following account of the cotton industry in this Presidency.

From the year 1903, when the cotton industry was revived, till the present time, the Government has purchased all the cotton grown by the peasantry, ginned it, and shipped the cleaned lint to England.

Progress in the industry was at first slow, but with the year 1907 keener interest was manifested and the rate of production was much increased. The increase was well maintained, until the crop of 1909-10, when, as will be seen from the table appended, there was a heavy falling off, the crop being less than half that of 1908-9.

This falling off must be ascribed to several causes, notable among which are the low prices which prevailed in the crop season of 1908-9, and bad weather. A certain amount of uncertainty as to the future of the industry in the Presidency also existed, and had considerable effect as regards the area planted in the season of 1909.

The crop of 1910-11 shows a satisfactory increase on the previous season's crop.

The industry in the Virgin Islands is entirely in the hands of peasantry; they are quite unaccustomed to regular and methodical agricultural effort, and in such circumstances it goes without saying that the cotton industry requires careful attention. There is no doubt, however, that cotton-growing is adding materially to the prosperity of the Presidency, and it bids fair to become its chief industry. The following table shows the weight and value of cott on shipped from the Virgin Islands for each year since 1904:—

Year.	Lint shipped, lb.	Value, £ s. d.			Increase, lb.	Increase, Value, £ s. d.		
1904	1,250	35	0	0	...	...		
1905	4,000	145	0	0	2,750	110	0	0
1906	7,807	265	0	0	3,807	120	0	0
1907	10,177	620	0	0	2,370	355	0	0
1908	32,520	1,800	0	0	22,343	1,180	0	0
1909	52,528	2,500	0	0	20,028	700	0	0
1910	23,139	1,520	0	0	29,389	980	0	0
1911	50,337	3,180	0	0	27,198	280	0	0
	181,758	10,065	0	0				

RUBBER IN THE DRIER WEST INDIAN ISLANDS, WITH SPECIAL REFERENCE TO ANTIGUA.

BY H. A. TEMPANY, B. SC.,

Superintendent of Agriculture for the Leeward Islands.

With the advance of rubber cultivation in present years, interest attaches to the possibility of extension in this direction in all tropical countries.

The most popular variety of rubber at present grown is *Hevea brasiliensis*, both by reason of the high yield of rubber obtained from it and its vigorous habit when it is grown under suitable conditions. For its successful cultivation, however, a comparatively high rainfall is essential; this applies also to *Funtumia elastica*, and in a smaller degree to *Castilloa elastica*; the latter and *Hevea brasiliensis* constitute the best known kinds of rubber-producing plants at the present time.

With rapidly extending knowledge, however, it becomes a matter of interest to ascertain whether kinds of rubber trees exist which are capable of being grown under the conditions obtaining in the drier West Indian Islands.

Of the West Indies, Antigua is probably the most noted for its liability to drought and small and uncertain rainfall. The average annual rainfall for the past thirty-seven years has been 45·10 inches. The amount of precipitation varies with the locality, and is highest in the southern and most mountainous district. It attains a maximum in the region of Wallings, where the Government reservoir for the supply of water to the country districts is situated; here the average annual rainfall for the past ten years has been 63 inches. As elsewhere in Antigua, however, the precipitation is subject to considerable fluctuations in amount, and long periods of drought are of not infrequent occurrence.

In 1905 and 1906, the attempt was made to ascertain if a number of varieties of rubber were capable of thriving under the conditions obtaining here. Between seventy and eighty seedlings of *Castilloa elastica* and a few specimens of *Funtumia elastica* and *Hevea brasiliensis* were planted out. Most of these trees received no attention, save an occasional cutlassing round when the surrounding bush threatened to choke their growth, and in general may be said to have been allowed to grow under natural conditions.

At the present time between thirty and forty of the Castilloas are alive, but the majority have made little growth and are badly attacked by scale insects. All the Heveas are dead, while two Funtumias remain, which though healthy, have made little progress.

A few Castilloas were established on the southern bank of the reservoir. By reason of their situation these plants occupied a more prominent position than the remainder, and have in consequence fared better, since, coming as they did immediately under the eyes of those responsible for the charge of the waterworks, a certain amount of care and cultivation was expended on them.

One of these trees made better growth than the remainder, and became an object of special care; in consequence it has made reasonable progress; at present it has a fairly promising appearance, is healthy and stands about 15 feet high.

The results tend to show that, given adequate care and cultivation, *Castilloa elastica* might be grown with moderate prospects of success, in this district. This bears out experience recorded elsewhere: that Castilloa thrives best under conditions of moderate rainfall, but that careful cultivation is requisite for it to give satisfactory results. When it is left to itself, it is unable to survive. In any case, the area capable of supporting it satisfactorily in Antigua would appear to be relatively very small, and the yields given by the plant, especially in the earlier stages of growth, seem to be meagre.

The plant *Hevea brasiliensis* appears to be unsuited to the conditions obtaining in Antigua, while *Funtumia elastica*,

although it has grown better than Hevea, does not appear to hold out much encouragement to intending cultvators.

Attention has been directed recently to certain members of the genus Manihot, in addition to *M. Glaziovii*, as rubber-producing plants. One of the chief characteristics of these is that they appear to thrive best in localities of relatively small rainfall; hence they are of especial interest to the dwellers in the drier islands such as Antigua.

Ceara rubber (*Manihot Glaziovii*) has long been known. It is a native of Brazil. A number of small plantations have been establised in Ceylon, Southern India and East Africa, but these have received little attention owing to the success attained with Para rubber cultivation, the relatively high yields of which render it much more attractive to cultivators in those localities in which it can be grown.

The Ceara rubber tree appears to be capable of being tapped when about five years old. The yields recorded vary considerably and are stated variously at from 1 to 4 lb. of latex per tree, per annum; for comparison it may be said that Para rubber, under favourable cultivation, will yield 4 to 8 lb. of rubber per tree, per annum. Properly prepared Ceara rubber is stated to be of great purity, being even superior to Para rubber in this respect.

A species of rubber-producing Manihot which has recently assumed prominence as a cultivable variety is Jequié Maniçoba rubber (*Manihot dichotoma*); extensive tracts of this species exist in Brazil, and the wild rubber from it is now said to constitute an appreciable fraction of the world's rubber supply. Accurate figures for the yields obtained from this are not at present available, but it is stated to yield larger returns than the Ceara variety; it is further said to be capable of being tapped when the tree has attained an age of four years. Two other species of Manihot have also attracted some attention recently; these are *Manihot piauhyensis* and *Manihot heptaphylla*, but little is known at present concerning the capabilities of these latter varieties. Specimens of *Manihot Glaziovii* have existed in Antigua for a number of years. At the Botanic Station, there is an example about ten years old which is a well-grown tree. A number of specimens also exist on McKinnons estate; they are about fifteen years old, and many of them became overgrown with bush and were lost sight of. Recent clearing on the estate resulted in their re-discovery. There are about eight or nine trees in all, and most of them are fairly well grown, the largest being about 25 feet high. The soil in which they are growing is thin and poor; and on the whole, the trees have well maintained their own under adverse conditions.

Trials of tapping the trees at the Botanic Station, Antigua, made in October 1910, showed a satisfactory flow of latex; and, contrary to experience recorded in Ceylon, there appeared to be a certain amount of wound response.

Seeds of *Manihot dichotoma* were received in 1907 from the Imperial Commissioner of Agriculture, and plants raised from them have given encouraging results. At Cades Bay, a number of plants exist, all of which are well grown, and one of these, eighteen months old, is about 8 feet high and is

growing well. The plant is raised easily from cuttings, and a ready means is thus provided for increasing the number of plants, once the tree is established.

There would appear to be some prospect that this variety will be capable of development as a source of rubber, under the conditions obtaining in Antigua, and of constituting an additional source of revenue. To enable more extensive trials to be made, 2,500 seeds have been imported recently, through the Imperial Commissioner of Agriculture. Plants from these are now being raised at the Botanic Station, Antigua, and will shortly be ready for distribution to planters who are willing to make trial of it on a small scale.

SOME NOTES ON RUBBER TREES IN DOMINICA.

BY J. JONES,

Curator of the Botanic Station, Dominica.

PARA RUBBER.

The first experiment in tapping Para rubber was made in Dominica during 1908, when three young trees were dealt with on successive mornings, for a short period. The biscuits of rubber obtained were forwarded to the International Rubber Exhibition held in London during that year. Samples were subjected to analysis at the Imperial Institute, and found to contain 93·4 per cent. of caoutchouc. The report on the samples stated that the rubber was of good quality, and compared favourably in composition with plantation Para rubber from Ceylon, and from the Federated Malay States.

The fact having been established that Para rubber of good quality could be produced in Dominica, it was decided, owing to the difficulty of obtaining supplies of seed of this tree, not to continue tapping, but to allow the trees to develop and fruit, in order to obtain assistance in meeting the local demand for seeds.

Some discussion having recently arisen regarding the yield from Para rubber trees in the West Indies, it was thought advisable to make a small experiment in tapping three trees, over a period of three months. The experiment was started on September 1, and ended on November 30, 1910. Tapping was carried on during the early hours of Mondays, Wednesdays and Fridays of each week, a total of thirty-nine tappings being made.

The yield in biscuit rubber was 3 lb. 3 oz., or a return of 1 lb. 1 oz. per tree, from three months' tapping. Similar trees under

estate management would be tapped during six months of the year, and the above return would be doubled, or nearly. The experiment, though on a small scale, appears to indicate that Para rubber trees may be expected to give a fair yield, in Dominica.

The irregularity in the size and thickness of the biscuits of the rubber is due to the difficulty of dealing satisfactorily with small quantities of latex. Also, in this connexion, a novice in the art of tapping cannot obtain such good results as men skilled by long experience in this form of work—a fact for which some allowance should be made when considering the Dominica experiment; this was carried out by a man unskilled in the tapping of Para rubber trees. The real test of yield must be judged by the amount of bark employed. In the above experiment, the bark of the tree to a height of 7 feet would be sufficient to last for four years, if tapped three times each week for three months in each year; or two years, if tapped three times weekly for six months in each year. With great skill in tapping, the bark might be made to last for longer periods than those named, or within a given period would allow of more cuts being made, with consequently an increased yield over the figures given above.

The following are the particulars of the age and size of the three trees tapped:—

	Age.	Height.	Girth, 3feet from ground.
No. 1	about 12 years	42 feet.	33 inches.
„ 2	8 „	32 „	24 „
„ 3	7 „	49 „	26 „

No. 1 is an isolated specimen growing on a lawn in a dry exposed position. No. 2 is a tree existing under rather better conditions than those surrounding No. 1. No. 3 is growing among other Heveas, under fair conditions as regards shelter. It is the most promising tree of the three.

The average annual rainfall at the Botanic Station, where the trees are growing, is 76·81 inches, which is considerably below the requirements of the Para rubber tree, and is representative only, in Dominica, of the rainfall on a narrow strip of land along the leeward coast. The precipitation in most other districts greatly exceeds this.

The implements used for tapping were Bowman & Northway's. The half-spiral method was adopted for cutting the bark. Cups were not used to collect the latex, as is the case in the East, but the sheathing base of a leaf of the cabbage palm (*Oreodoxa oleracea*) was tacked round the tree, near the base of the trunk, in such a way as to collect the latex and deliver it into a single receptacle. After tapping, the trunk is washed with a fine spray of water from a force pump. By these means the whole of the latex is obtained, and there is no scrap rubber. The leaf sheath is tough enough to last for a season's tapping—that is for five or six months.

The mixture of latex and water is carefully strained and placed in a suitable vessel. A little lime juice is then added, which effects coagulation within five or six hours. The cake of

rubber, white in colour, is then ready to be lifted out. It should be washed in clear running water, in order to remove as much of the acid as possible, and other impurities; and afterwards pressed and dried. When cured, the biscuits are amber-coloured.

The area planted with Para rubber in Dominica is probably about 200 acres. Plants to the number of 15,000 have (up to the end of 1910) been distributed from the Botanic Station. In addition, a number of plants have been raised by planters in their own nurseries. There are prospects of a considerable development of this cultivation in the near future, if seeds can be obtained in sufficient quantities and successfully germinated. Hitherto, the importation of Para rubber seeds has been, on the whole, successful. The last importation, of 21,000 seeds, yielded 60 per cent. of plants.

A promising feature of Para rubber is its suitability for districts in which the rainfall is too heavy for cacao cultivation. The young trees are very promising in localities with an annual rainfall ranging from 120 to 200 inches. With regard to the soil, there are indications that Para rubber is likely to succeed better on the red soils of the uplands than on the black soils of the valleys.

The effect of heavy gales, which occasionally sweep over the West Indian Islands, on Para rubber trees, is as yet unknown. It is satisfactory to note in this respect that young Hevea trees in Fiji were but little injured by the hurricane that passed over the islands in March 1910. Planters would, however, be well advised to give the cultivation as much shelter as possible. If the trees are planted on exposed lands, the precaution of protecting the area effectively, by means of wind-belts, should be taken.

FICUS ELASTICA.

During the past season (1909-10), a fifteen year old tree of *Ficus elastica*, growing in the Botanic Gardens, was tapped on eight mornings during June, four times in September and once in October and in November, making a total of 14 tappings, for the purpose of testing the yield and quality of the rubber.

The latex was collected in tin cups, fitted with a small spike which enabled them to be stuck on the branches, immediately below the cuts made in the bark. In each cup a small quantity of water was placed to prevent the latex from coagulating.

After collection, the cakes of rubber were prepared by passing the mixture of latex and water through fine muslin, to remove all mechanical impurities such as bark and dirt. A small quantity of carbolic acid solution containing about 1 per cent. of the acid was then added, and the whole stirred well. The latex was poured into shallow receptacles (ordinary breakfast saucers do well); these were then placed in a cool airy position in the shade, a fine wire gauze being put on the top in order to prevent the access of insects, etc. In about 14 days the water evaporated, leaving a thin cake of rubber of good colour and appearance. If the cake is not treated with carbolic

acid or formalin, the rubber turns quite black. Coagulation of this rubber may also be effected by boiling the mixture of latex and water.

The yield, in cured rubber, from the above tappings amounted to 2½ lb.

Samples of the rubber were forwarded to the Government laboratory, Antigua, for analysis, and the following report was furnished by the Government Chemist:—

The sample consisted of a portion of a single biscuit of rubber, and weighed 17 grams.

Analysis showed it to have the following composition:—

	1. Sample as received.	2. Analysis calculated for dry rubber.
Moisture	1·7	
Caoutchouc	85·55	87·0
Resin	10·2	10·4
Protein	1·05	1·1
Ash	1·5	1·5
Insoluble matter	0·0	0·0
	100·00	100·00

The sample was dark-brown in colour and was a trifle sticky; it showed fairly good elasticity and tenacity.

Comparison with analysis of *Ficus elastica* rubbers from India showed this sample to be decidedly superior to them from the point of view of caoutchouc content, though the fact that it is somewhat sticky would appear to be unfavourable to some extent.

The report shows that some improvement is needed in the preparation, in order to obtain rubber without a suspicion of stickiness.

It would appear that in *Ficus elastica*—a comparatively rare tree in the West Indian Islands—there exists a hardy rubber tree which might be utilized to a considerable extent in planting ridges, in forming wind-belts for the protection of other rubber cultivations, such as Para rubber, and generally for planting on waste lands.

The tree grows with great vigour in Dominica, is easily propagated by cuttings in the open, and by axillary buds with one half of a leaf attached, if it is kept in a close atmosphere until growth has started. For purposes of rubber production it would appear that trees raised from seeds are the best, as such form aerial roots freely, enabling the trees to spread, thus affording new areas for tapping. Trees raised from cuttings and buds produce very few aerial roots, and in some cases none at all. That trees raised from cuttings and buds are capable of giving a fair yield of rubber is proved by the above experiment, the fifteen-year-old tree mentioned having been raised from a bud.

It should be clearly understood that *Ficus elastica* is not recommended for systematic cultivation, but its use is suggested

for forming wind-belts, owing to the firm hold of its roots in the ground, its capability of resisting the wind, and to the fact that it yields a good rubber. It should also be useful for planting on steep hillsides, which have in many instances been cleared and afterwards found too steep for cacao and lime cultivations.

THE CADET SYSTEM IN ANTIGUA AND ST. KITTS.*

The cadet system, which is now finding a place in the organization of the Botanic Stations throughout the West Indies, originated at the Botanic Stations of Antigua and St. Kitts in 1907, and it is of interest to record briefly the experience obtained as a result of the working of the system in the two places.

The object of the cadetships is to afford some training in the practical side of agricultural work for boys who intend to take up planting as a profession; while at the same time an insight into agricultural science is given, from the point of view of the experiment station.

The cadetships are awarded on the recommendation of the Imperial Commissioner of Agriculture, and are tenable at the Grammar Schools of the Presidencies and under the Agricultural Department. The status of the cadets is that of Grammar School Scholars. They are appointed for a term of one year, subject to extension under certain conditions; they receive a grant of 5s. a week from the funds of the Agricultural Department. This is not intended as wages, but rather as a means of accustoming the boys to the possession of small sums of money, and for developing a sense of responsibility.

At the Grammar Schools, the cadets attend classes under the Agricultural Science Master, and receive training in agricultural science and other subjects.

At the Botanic and Experiment Stations, they become acquainted with necessary work such as grafting, budding, potting, laying out of experiments and the general outdoor routine work of the agricultural department. They are also afforded elementary training in laboratory work, such as the examination of cotton samples, and the simple analysis of cane juices. In addition, experience is obtained in handling labour, making up accounts and pay sheets, and writing up records.

In Antigua there are at present two cadetships; one of these is officially attached to the Botanic Station, and the other to the Government Laboratory, but the training in both is essentially similar, and in each some time is spent both at the Laboratory and the Botanic Station.

In connexion with the cadetships, the position of Assistant for Agricultural Experiments is maintained as an appointment

*This note on the cadet system in Antigua and St Kitts has been contributed by Messrs. H. A. Tempany and T. Jackson, in Antigua, and F. R. Shepherd in St. Kitts. [Ed., *W.I.B.*]

in training to be held for a limited number of years, the holders of the position being recruited from time to time from the cadets.

The first appointment of a cadet at the Antigua Botanic Station was made in September 1907 ; the holder was selected for the post of Assistant for Agricultural Experiments in the following year, which position he occupied until October 1910, when under the terms governing the appointment he relinquished it to take up work subsequently as an overseer on a cacao plantation in Grenada. The second cadetship was established at the close of 1909. In all, seven boys have so far held cadetships under the Department in Antigua. At the present time, four of these have taken up positions as overseers on estates, one at present holds the appointment of Assistant for Agricultural Experiments, and two are now in training at the Station. The boys are required to keep a note-book in which are entered the operations performed by themselves; these are periodically inspected and signed by the Officers in charge. Periodical reports on the boys' work, both at the Grammar School and under the Department, are sent to the boys' parents, and to the Commissioner of Agriculture.

In St. Kitts, the system is worked on similar lines to those followed in Antigua.

The first cadet was admitted to the Station in July 1907, and after serving one and a half years, was appointed to act as Foreman of the Botanic Station, which post has thus become converted into an appointment in training somewhat similar to that of the Assistant for Agricultural Experiments in Antigua.

At present, there are two cadets at the Botanic Station and they in turn spend one week at the Botanic Station and one week at the Experiment Station, La Guérite ; by this means they obtain a broad view of the work carried on. In addition, during the reaping of the sugar-cane experiments, they assist in the laboratory work connected with the analysis of the juices from the experiment plots.

Cadets are required to enter for the Reading Courses and Examinations in Practical Agriculture, of the Department. One of the cadets at present attached to the Station in St. Kitts has passed the Senior Cambridge Local Examination in Agricultural Science, which exempts him from the Preliminary Examination of these courses. Of the others, all these, with the exception of the cadet recently appointed to the Antigua Station, have sat for, and passed, satisfactory Preliminary Examinations. In Antigua, one of the former cadets passed the Intermediate Examination held in November 1910.

In Antigua, a ready demand exists for the services of boys trained in this way for posts as overseers on estates ; in course of time it is hoped that the scheme will do much to raise the status of overseers employed on estates, which in the past has sunk to a low level. The existence of a steadily increasing body of men, trained to some extent in the habit of observation on systematic lines, filling the junior positions in the planting profession in these islands must, it is felt, have a decidedly beneficial influence on agricultural practice, and in addition will supply a reliable source for recruiting for the senior appointments in years to come.

AN ACCOUNT OF THE RETURN OF VEGETATION AND THE REVIVAL OF AGRICULTURE, IN THE AREA DEVASTATED BY THE SOUFRIERE OF ST. VINCENT IN 1902-3.

BY W. N. SANDS, Agricultural Superintendent, St. Vincent.

It will be remembered that the Soufrière volcano, situated at the northern end of the island of St. Vincent, broke out into violent eruption on May 7, 1902, with the result that several hundred people were killed, a large area of land was utterly devastated and a number of valuable estates completely ruined.

The general effects of the eruptions, and the phenomena associated with them,* have been fully investigated by several well-known scientists. Briefly, it might be stated that from May 1902 to March 1903, the volcano was very active and several eruptions of considerable magnitude occurred, accompanied by incandescent avalanches.† These avalanches burnt off all the vegetation on the slopes of the mountain and the surrounding districts, and covered the land with a large deposit of ejecta. It has been estimated that one-third of the island, or an area of about 50 square miles, was devastated, in varying degrees. The districts which suffered most severely were situated on the west and east slopes of the volcano, and extended from Richmond estate to Windsor Forest on the west, and from Georgetown to Overland Village on the east. The area of these districts is approximately 20 square miles. Within this area were several flourishing estates whose lands were considered to be the most fertile in the island.

It was chiefly with the object of studying the plants, and also certain agricultural methods which were likely to be of most service in aiding planters in this part of the island to reclaim the devastated lands, that several visits, since the year 1904, have been paid to the Soufrière and the districts named above.

It might be mentioned at the outset that the flora of St. Vincent is rich and varied, and has been very closely studied by botanists. The number of species already found amounts, according to the *Kew Bulletin* No. 81, p. 294, 1903, to about 1,150. Previous to the eruptions, the districts devastated had a rich flora. Up to a height of nearly 2,000 feet the slopes of the Soufrière were covered with a luxuriant tropical forest growth. Above this, and almost reaching the summit, there were shrubby plants, ferns, and mosses. Inside the crater, also, shrubs, ferns and other plants were to be found.

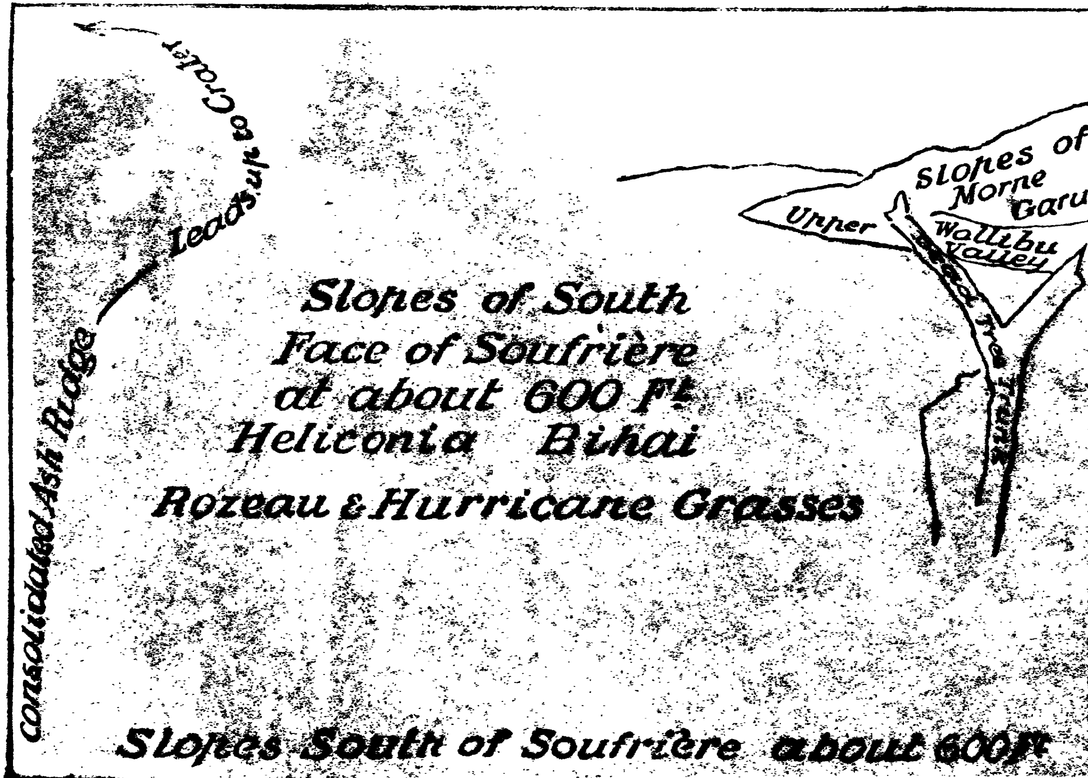
The effect of the eruptions was completely to destroy all vegetative growth above the surface of the earth, except in

---

* Anderson and Flett. Report on the eruptions of the Soufrière in St. Vincent, in 1902, and a visit to Montagne Pelée, in Martinique. Part I. *Philosophical Transactions of the Royal Society*, Series A, Vol. 200, pp. 552-3. 1903.

Ditto. Part II. loc. cit., Vol. 208, pp. 275-352.

†See Anderson and Flett. Part I, loc. cit., pp. 447 to 56 and 506 to 14.


Leads up to Crater
Consolidated Ash Ridge
Slopes of Morne Garu
Upper
Wallibu Valley
Tree Trunk
Slopes of South
Face of Soufrière
at about 600 Ft
Heliconia Bihai
Rozeau & Hurricane Grasses
Slopes South of Soufrière about 600 ft

SOUTH SLOPES OF SOUFRIERE AT ABOUT 600 FEET.
(From *Phil. Trans.* A. Vol. 208, Plate 23, Fig. 1.)

sheltered situations ; so much so that the whole area presented an absolutely desolate appearance, a few badly burned trunks of forest trees alone standing.

The depth of the covering of ejecta varied a good deal in different places ; for instance, in some of the valleys it was from 50 to 80 feet thick ; on fairly level land from 1 to 5 feet ; whereas on steep slopes it was only a few inches deep.

From a botanical point of view, the features connected with the return of vegetation are not as interesting as those described by the late M. Treub and Professor O. Penzig in the case of Krakatoa,* where, as is well known, the whole island was, in the year 1883, rendered perfectly sterile, and all plant life had to be introduced over long distances by means of ocean currents, wind, or by birds, and where every development could be clearly traced. In St. Vincent, as is mentioned above, only a part of the island was devastated, and as it will be shown later, even in the area badly affected a good deal of vegetative life remained ; still it may be interesting to put on record a few observations.†

On arriving at the edge of the devastated area on the leeward side of the island, and looking towards the Soufrière from the higher lands of Richmond estate, it is at once seen that, notwithstanding that the last eruption took place but a few years ago, the lower lands are all fairly well covered with vegetation in the form of low bush; as are also the slopes of the mountain up to about 2,000 feet. Starting from the ruined Richmond plantation works, it is seen that the ejecta, mixed to some extent with old soil brought down by rains from the higher lands above, are from 2 to 6 feet thick, and are being rapidly converted into soil under the influence of favourable climatic conditions, the action of the roots of various plants and decaying organic matter. Quite a large number of species of plants has sprung up, and these are to be seen growing luxuriantly in large masses; among them is the cattle-tongue (*Pluchea odorata*, Cass.); Indigo (*Indigofera Anil*, L.), Castor-oil (*Ricinus communis*, L.), Sensitive plant (*Mimosa pudica*, L.), *Eupatorium odoratum*, L., Wild hop (*Flemingia strobilifera*, R.Br.), Hurricane grass (*Arundinella martinicensis*, Trin.), Roseau grass (*Gynerium saccharoides*, H.B.K.), Guinea grass (*Panicum maximum*, Jacq.), Verbena (*Stachytarpheta jamaicensis*, Vahl.), *Urena lobata*, L., and a small shrubby *Cassia* sp. With the exception of the Roseau grass, the roots of which had not been killed, all the plants have gradually established themselves from seed brought by various agencies from lands near by. A few trees near the estate works, and in sheltered spots on the hillsides, although badly burned, have also survived : these are the silk cotton (*Eriodendron anfractuosum*, D.C.); West Indian walnut (*Andira inermis*, H.B.K.) ; Fiddlewood (*Citharexylum quadrangulare*, Jacq.); and quite a large number of Gru-Gru palms (*Acrocomia lasiospatha*, Mart.). Altogether there is evidence of a quick return to normal conditions.

From Richmond works, proceeding along the coast in the direction of the volcano, a plateau of ash is soon reached which

---

* *Annales du Jardin Botanique de Buitenzorg*, Vol. 7, 1888 ; Vol. 18, 1902.

† Anderson, loc. cit., Part II, pp. 286-8, and cp. Martinique, p. 301.

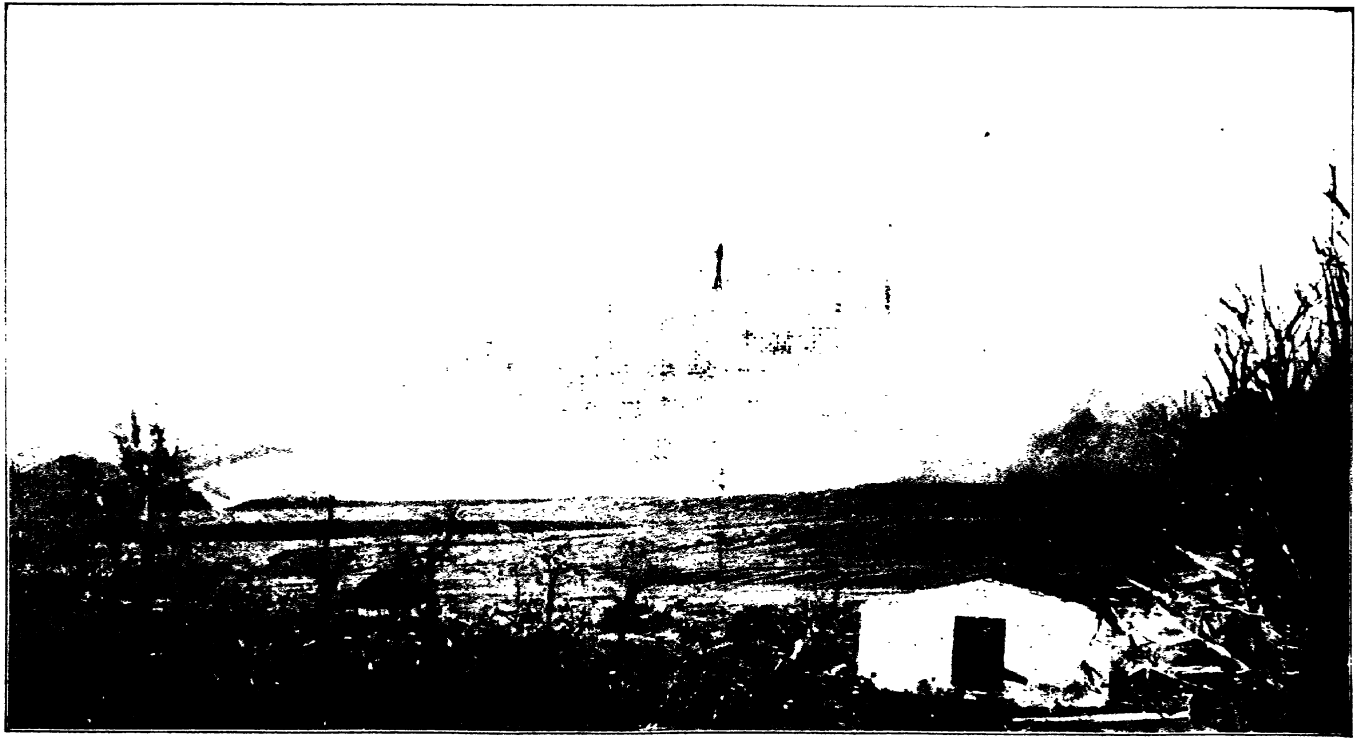
was put down in the form of an incandescent avalanche. This avalanche destroyed Richmond village, and covered the north-west portion of the plantation lands to a depth of several feet. It is observed that the top layer of ash has formed a crust, but this has been broken up at frequent intervals by heavy rains; the result is that numerous shallow water-channels have been formed. It is observed that it is only in these depressions that plants have been able to get a root-hold. The chief plant lining the sides is the silver fern (*Gymnogramme calomelanos*, Kaulf.), which is playing the important part of preparing the ash for higher types. Already a few hardy plants such as the hurricane grass (*Arundinella martinicensis*, Trin.), *Emilia sonchifolia*, D.C., cattle-tongue (*Pluchea odorata*, Cass.), *Eupatorium odoratum*, L., and a sedge or two are found growing with the ferns. Here it is evident that these are the true ash plants, and have grown from spores and fruits brought by wind and water; but chiefly by the former. Estate animals have lately been allowed to roam over the ash on their way to the higher lands at the back, and have broken up the crust between the channels to a considerable extent, so that there appears little doubt that this tract will soon be completely covered with herbaceous plants, shrubs and grasses.

Just at the back, there is a ridge from which a large proportion of the ash has been washed off by rain. This is completely covered with large masses of the cattle-tongue plant. It is at once seen that this plant and the silver fern are two of the most useful pioneers on the lower lands of the leeward side. The cattle-tongue already covers a large area, and it still continues to spread rapidly, for its pappus-topped fruits are produced in great abundance, and are easily carried long distances by the wind.

On reaching Wallibu estate, which is situated at the foot of the mountain and suffered very severely, somewhat similar conditions to those seen at Richmond estate are to be noted; the fairly level fields are cut up by water channels in which silver ferns, cattle-tongue and hurricane grass plants predominate. At the back of the ruined and partially covered estate works is a steep bank facing the sea, which is completely covered with a rich growth of bamboo (*Bambusa vulgaris*), *Heliconia Bihai*, Sw., *Ipomoea cathartica*, Poir, *Ipomoea umbellata*, Mey., *Philodendron* sp. The surface of this bank, although sheltered from the full blast of the eruptions, was completely denuded of all growth; but the roots of the plants were not killed and they were soon able to recover. Except that there are no trees, other than one or two solitary gru-gru palms, the vegetation is fairly well restored.

In very sheltered spots up the Wallibu River gorge it is noticed that vegetation has become established in much the same manner, but that the steep banks on each side of the river are still very bare; however, silver ferns, cattle-tongue and Ipomoeas have already got a firm hold on ledges and crevices.

Commencing the ascent of the Soufrière by way of the Trespé gorge, the same species of plants as in the Wallibu River gorge are seen, except that they have made a greater advance. Here the vines (Ipomoeas) hang down over the banks in great profusion and in places cover large areas. A good number of



Carib Country: Cane Fields.
(From *Phil. Trans.* A, Vol. 200, Plate 31, Fig. 1.)

other plants are observed, but not in quantity, among them being *Passiflora foetida*, L., *Emilia sonchifolia*, D.C., *Erigeron bonariensis*, Griseb., *Capraria biflora*, L., Bamboo grass (*Ischaemum latifolium*, Kunth.), *Eupatorium odoratum*, L., and verbena (*Stachytarpheta jamaicensis*, Vahl.).

Leaving the Trespé valley, and mounting a ridge, the top of which forms a fairly good track, it is noted that the greater part of the ash deposit—never very thick on the slopes—has been washed away. In many places the old soil can be seen. In all directions a large number of different plants is covering the sides of the ridges, and already quite a dense growth of shrubs, climbers, grasses and other plants has been formed, through which a track has to be cut. It is very evident that the greater part of this vegetation has become established from roots and seeds whose vitality was not destroyed by the eruptions. There are no trees; these were killed outright, and only a few charred trunks, in many cases covered with Ipomoeas, remain as evidence of the former forest growth; these, however, will soon appear, for already young seedlings can be detected growing in the valleys. To give a list of all the plants seen would take up too much space; those, however, commonly occurring in large masses, are the Roseau grass, Heliconia, Bamboo grass, *Ipomoea umbellata* and *I. cathartica*, silver fern, verbena, *Vitis sicyoides*, and hurricane grass; also several melastomaceous and rubiaceous bushes. Occasionally, the site of a former negro garden is passed, with plants of sugar-cane, banana, and plantain as the chief survivors. This type of vegetation continues up to an altitude of about 600 feet. Between 600 feet and 1,000 feet there is not much change, except that there are large masses of young tree-ferns (*Cyathea arborea*, Smith), the bushy *Trema lamarckiana*, B.L., and two Psychotrias which bear pretty red berries. At 1,400 feet, plants are scantily distributed and the growth is poor. Only the hardy bamboo and Roseau grasses, silver ferns and tree-ferns, *Freziera hirsuta*, Sw., and *Eupatorium odoratum*, L., appear to thrive. Here, however, is found the pretty moss *Lycopodium cernuum*, L., and the somewhat rare *Eupatorium osseanum*, D.C. At 2,000 feet, silver ferns and mosses only are seen. From this altitude to the lower lip of the crater, which aneroid barometer readings indicate to be 2,800 feet above sea-level, the ejecta assume a coarse, cindery form, in which at present only algae, mosses, and lichens are able to exist. Around the edge of the crater, and inside for a short distance down, only two mosses, a lichen which grows in distinct circular patches, and algae, are found. The mosses have been kindly identified by the authorities of the Royal Botanic Gardens, Kew, as *Pogonatum tortile*, P. Beav.; and *Philonotis tenella*, Jacq., and the lichen as *Stereocaulon* sp. *

There is no sign of any higher types; these will no doubt arrive as soon as the lower forms above named have played their part and prepared the soil for them.

On making a trip by canoe along the coast from the mouth of the Trespé gorge to Windsor Forest, it is observed that the vegetation on the slopes of the mountain has returned in a similar

*Anderson, loc. cit., Part II, pp. 286-8; and cp. Martinique, p. 201.

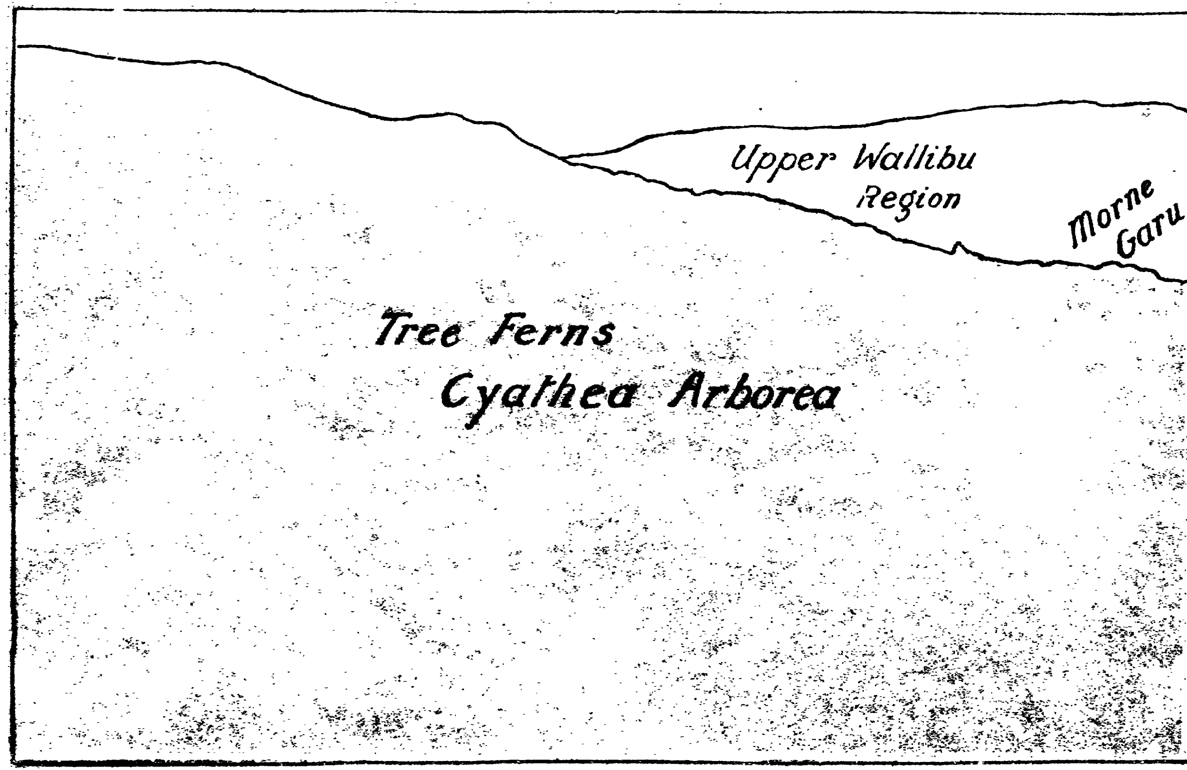
manner to that described above, only there are quite a number of trees to be seen, among them being the Trumpet tree (*Cecropia peltata*), Bois Flot (*Ochroma Lagopus*), and Fiddlewood (*Citharexylum quadrangulare*).

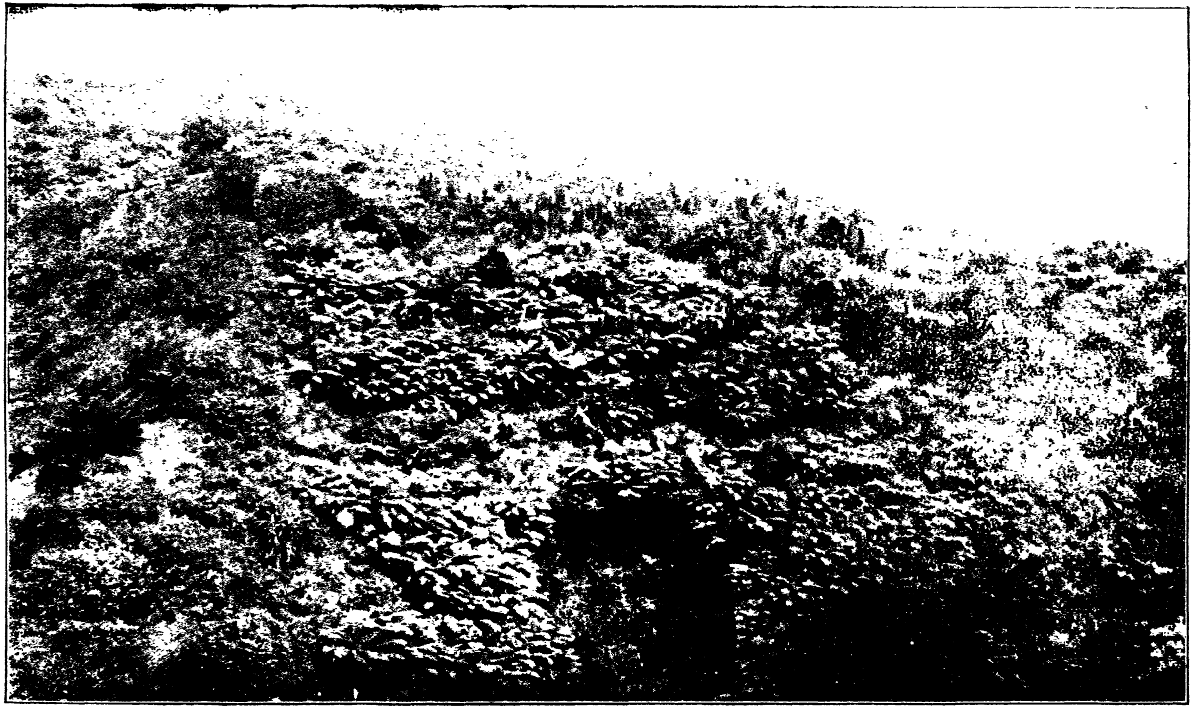
So far, cultivation in the devastated area on the leeward side has only been attempted at Richmond estate. Here, by a system of deep tillage and by utilizing green dressings, large quantities of the bush of the pigeon pea, and self-sown native plants such as wild hops (*Flemingia strobilifera*), and cattle-tongue (*Pluchea odorata*), fair crops of sugar-cane, arrowroot, and pigeon peas have been produced. The lands on which these crops have been grown had, when taken up, about 12 inches of ash covering them, but this ash had been partly converted into soil by the large growth of native plants of the previous three or four years. It still requires, however, very heavy applications of manure and organic matter to make it capable of producing average crops.

The devasted area on the windward side presents a picture quite different from that of the leeward. On reaching the top of a hill about a mile south of Georgetown, a good view of nearly the whole of the district is obtained. It is seen that a considerable portion of the broad plain, known as the Carib Country, is under cultivation in sugar-cane, cotton, arrowroot, pigeon peas and other crops. From this point, scarcely anything can be seen to indicate that, in 1903, the whole district had the appearance of a waste of ashes and cinders. It is also observed that the slopes of the volcano at the back are even more completely covered with the vegetation than those on the leeward side. Several of the estate buildings on the plain have been reconstructed, and here and there are to be seen the small villages recently built for the estate labourers. Looking at the condition of estates to-day, one cannot but admire the energy and enterprise of these owners who have been reponsible for their speedy resuscitation. Taken altogether, the first impression one gets of the district is most pleasing.

On inspecting the plants growing on the lower lands, near the sea, many more species than in the leeward devasted district are found. This is due to the fact that the avalanches of hot ash had a longer distance to travel, and cooled somewhat by the time they reached these lands ; so that the destruction was not so complete. Quite a large number of trees which were badly burnt are to be seen growing by roadsides, near the estate buildings and along the line of the canal which supplied water to several of the estates. These are the silk cotton tree (*Eriodendron anfractuosum*, D.C.), *Melia Azedarach*, L, mango (*Mangifera indica*, L.), hog plum (*Spondias lutea*, L.), red plum (*Spondias lutea*, L.), Mammе apple tree (*Mammea americana*, L.), Bois Flot *(*Ochroma Lagopus*, Sw.), mahoe (*Thespesia populnea* L.), guava (*Psidium Guyava*, Raddi.), walnut (*Andira inermis* H.B.K.), tamarind (*Tamarindus indica*, L.), West Indian almond (*Terminalia Catappa*, L.), bread fruit (*Artocarpus incisa*, L.), seaside grape (*Coccoloba uvifera*, Jacq.), and one or two others.

***Also known as the down tree and bombast mahoe in some parts of the West Indies.**


Upper Wallibu
Region
Morne
Garu
Tree Ferns
Cyathea Arborea



Slopes of Soufriere at About 800 Feet.
(From *Phil. Trans.*, A., Vol. 208, Plate 23, Fig. 2.)

The other types growing in the districts are very numerous. They include nearly all those already described on the leeward side and are found in similar situations, but here *Eupatorium odoratum* takes the place of *Pluchea odorata*, and grows in profusion. *Momordica Charantia*, L. and the pretty little periwinkles (*Vinca rosea* and *Vinca rosea*, var, *alba*) are also seen almost everywhere. The bulk of the plants is, however, growing in places where the ash has been washed off by rain, or where it has been mixed with the old soil in the process of cultivation. On lands where the covering of new ash is very deep, only silver ferns, *Eupatorium odoratum*, *Momordica Charantia* and one or two hardy grasses and sedges are found growing in the depressions formed by rain. The vegetation on the mountain slopes has returned in much the same manner as that on the leeward slopes, and presents similar features.

As is mentioned above, the fairly level estate lands have been in a large measure reclaimed. The story of how they were made to produce average crops of estate produce within a year after the last eruption is of much interest.

If holes are dug through the ash to the old soil in parts of the fairly level lower lands as yet untouched, it is seen that the average depth of the ejecta is 13 inches, and that these are made up of three definite layers each possessing distinct characteristics. The three eruptions, during which the bulk of the ejecta was deposited, occurred in May and October 1902, and March 1903. From records made at the time in the district, it was estimated that the deposit in May was from 1 to 3 feet thick, in October 6 to 8 inches; and in March 2 to 3 inches,* or an average of 2 feet.

The heavy rains and floods since the eruptions have of course washed away immense quantities of it, and besides, it has become very compact; the result is, that as is mentioned above, the deposit now averages 13 inches only. The first layer put down is known as the 'May dust', and was chiefly composed of a very fine grey dust which quickly consolidated and formed a hard concrete-like pan. The October and March layers were composed of much coarser particles, largely of a sandy and cindery nature, free and easily worked. Analyses of the ash made soon after the eruptions showed that it possessed little fertilizing value; it was however stated locally that, after the 1812 eruption, the ash which fell had a beneficial effect on the crops of the following years: at any rate, it is on record that the amount of sugar and rum made in 1813 was equal to that of 1812; still it must be noted that the covering of ash on this occasion was only from 6 to 10 inches deep. In June 1904, when this district was first visited, it was an agreeable surprise to find, in nearly all the fields which had growing sugar-cane at the time of the May eruption, that quite a large number of plants had been able to send up shoots through the deep covering of ash, and were growing well. This fact, together with a further example at Orange Hill mill-yard, led some

---

*Anderson and Flett, loc. cit., Part I, p. 426 and pp. 428-40.
Anderson, loc. cit., Part II, p. 290.
" " " " " pp. 294 and 295.

planters to believe that the ash possessed valuable fertilizing properties, and they were strengthened in this opinion by stories of the beneficial effect of the ash of the 1812 eruption.

Particular stress was laid on the Orange Hill case. Here, on the day of the great May eruption, sugar was being made at the estate works, and in the mill-yard there was a large heap of canes piled up ready for grinding. This heap was of course covered with hot ash: however, some of the canes in it were not destroyed, and these quickly pushed up shoots through the ash, and a most luxuriant growth of cane was eventually made. The conclusion immediately arrived at was that the ash was the sole cause, and further that it was safe to replant the devasted fields in sugar-cane and other crops in the ash alone. A few fields were planted, but it was very soon seen that something was wanting, for in every case absolute failure resulted. Even the hardy pigeon pea would not grow, notwithstanding that it is capable of collecting a considerable portion of its food from the atmosphere. The obvious explanation of the Orange Hill mill-yard case on which so much stress was laid, is, that the roots of those few canes that survived had all the decaying organic matter provided by the rest of the heap to feed on, and were most likely able to come into contact with the old soil.

In order to ascertain by definite experiment if the ejecta of 1902-3 really had any agricultural value, the Imperial Department of Agriculture, in January 1903, started a small experiment station, near Georgetown, and made tests in $\frac{1}{10}$ acre plots with sugar-cane, arrowroot, sweet potatoes, and ground nuts.* The experiments were carried out in four series:-

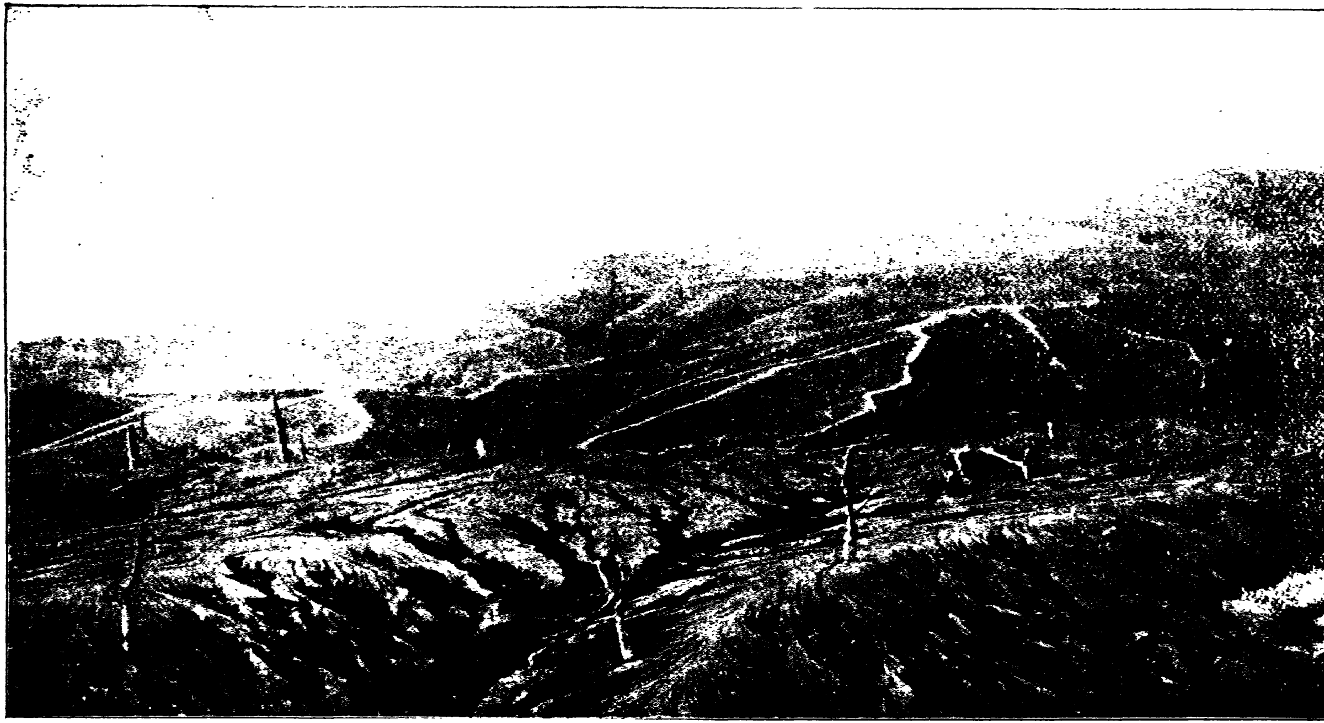
(a) in the old soil alone,
(b) „ „ „ „ mixed with the May ash,
(c) „ „ „ „ „ „ „ May and October ash,
(d) „ the May and October ash alone.

After the experiments were started, the March eruption which deposited a light layer of cindery ash, occurred. This deposit could not be taken into account.

The result of the first year's trial gave abundant additional evidence of the fact that the ash alone could not support the higher types of plant life. For instance, sugar cane grew fairly well in series (a), (b) and (c), but in (d) scarcely any growth was made. The best results were obtained from (c)—old soil and May and October ash mixed. Arrowroot did fairly well in the old soil, and in old soil mixed with ash, but very poorly in the ash. Practically the same results were obtained with sweet potatoes; and the ground nut, although it is a leguminous plant could not produce a crop except there was some admixture of the old soil.

At the time these trials were in progress, extensive experiments were being conducted on the neighbouring estates, one of which has already been described. The results were in every case in accord with those obtained at the experiment station.

*See Annual Report on the Botanic Station, etc., St. Vincent, 1903-4, pp. 8 and 9, and 1904-5, p. 8



HIGHER CARIB COUNTRY AND BASE OF SOUFRIERE.
(From *Phil. Trans.*, A. Vol. 200, Plate 23, Fig. 2.)

The conclusions arrived at were :—

(1) that, provided the soil is mixed with the ash, fair crops of estate produce can be successfully grown.

(2) that the ash alone does not in itself contain sufficient food constituents to support plant life.

(3) that on land covered with a thick layer of ash, only a system of deep cultivation through to the old soil will enable crops to be grown with any chance of success.

Bearing these facts in mind, it was then found necessary to devise means for dealing with the ash-covered lands so as to make them produce paying crops. The methods which were at length found to answer well were as follows.

For sugar-cane, the land was banked much higher than usual, and then cross-holed until the bottom of each hole exposed the old soil; the canes were then planted in this. Lands for arrowroot, cotton, ground nuts, sweet potatoes, and cassava were deeply trenched through to the old soil. This was of course a slow and laborious process, but it was cheerfully undertaken by the peasantry, who were glad to obtain portions of the lands for a year or two as provision grounds. The depth of the trenching was often from 18 inches to 2 feet. The ash removed in the process of trenching was placed in the bottom of the trench and covered with 3 or 4 inches of the old soil. Pigeon peas were, as a rule, planted on small mounds 10 feet by 10 feet apart, composed of a mixture of ash and old soil. The space between the mounds was not trenched. Whatever method was adopted, care was taken to break up the hard pan in contact with the old soil.

The resulting crops of sugar-cane were quite up to the average of those obtained before the eruptions, and in some cases better. Arrowroot, however, only gave a fair yield. Sweet potatoes and cassava bore well, as also did ground nuts. Pigeon peas grew most luxuriantly, and completely covered the space between the mounds: often, it was not possible to reach the tops of the bushes from horseback. The roots invariably possessed a large number of the nitrogen-collecting nodules. Sea Island cotton, although extensively planted on lands that were trenched, and on lands on which two or three crops of sugar-cane had been grown, has so far, given very low average yields; but there are indications that in the near future satisfactory results will be obtained. The vegetative growth made was all that could be desired: yet there was something lacking, for very few bolls per plant ever matured. Possibly this was on account of a want of potash. It will be noted that all the other crops—with the exception of the leguminous ones, which are more independent of certain food constituents—are grown for the sake of certain vegetative parts. Cotton, on the other hand, is the only crop grown for the sake of its seed (seed-cotton). It thus appears as if certain necessary food materials are not available in sufficient quantity; but there may be other factors, having a limiting effect on the crop, which are not evident.*

*See also *Agricultural News*, Vol. V, p. 381; *West Indian Bulletin*, Vol. III, p. 271

One thing is already shown, and that is, the light ashy soil that has been worked now requires frequent applications of organic matter in order to maintain its fertility. The method at present being adopted of adding large quantities of pen manure, and of growing leguminous plants for use as green dressings, appears to be in the right direction.

It will be noted that it has been found possible, by carrying out a definite system of cultivation, to obtain average crops of estate produce, with the exception of cotton; but there are still features of much interest in connexion with the effect of the ash on the nature and fertility of the soil which might be discussed.

The chief feature, as already seen, was that the ash in itself could not support plant life—not a single crop could be successfully grown in it—but no sooner was a certain proportion of old soil mixed with it, or the plants were placed in the old soil, than crops, in some cases above the average of those produced before the eruptions, were obtained without the addition of manure; but only for one, and sometimes two years, after the lands were put into cultivation. That this temporary increase in fertility was not entirely due to deep cultivation is evident by the fact that only the upper 3 or 4 inches of the old soil were touched in the process, and that it is now necessary to manure heavily to obtain average crops. The qestion arises as to the cause of this temporary increase in fertility after the eruptions. An endeavour has been made to show that it was not due to the presence of any available food materials in the ash, or any improvement in the physical condition of the soil, so that a search must be made elsewhere for a possible solution of the problem, and that, it is believed, will be found by applying the results of recent discoveries in connexion with the bacteria of the soil, and the effect of certain of these, and other micro-organisms on the fertility of the soil.

The following extracts have been taken from an article published in the *Agricultural News*, Vol. IX, pp. 33, 34. In this article the results of experiments, more particularly those of Russell and Hutchinson, at Rothamsted, on the effects of sterilization on the balance of life in the soil, are discussed. After giving details of the manner in which the experiments were conducted, it is stated :—

'The first result obtained in the experiments was that "the increased productiveness of partially sterilized soil is due to an increase in the amount of ammonia present." Considering the partially sterilized soils, it was found that at the end of twenty-four days the soil that had been heated to 98° C. showed the greatest increase in the amount of ammonia present. . . . . Other effects of partial sterilization were found to be an increase in the rate of production of unstable nitrogen compounds and the destruction of nitrifying organisms.' The conclusions arrived at by the investigators are thus summarized. It would appear: 'that the number of bacteria in the soil is limited by the presence of comparatively large, competing and destructive organisms, and that the increased fertility of soils that have been partially sterilized, is due to the killing of these, and the consequent

increase in the rate of production of bacteria, with the concomitant increase in the rate of formation of ammonia.'

How, then, can these results be made to apply? The old soil, as is previously noted, was covered with about 2 feet of hot, sterile ash. The effect of this would be to bring about a partial sterilization of the soil, and interfere with the balance between the different forms of living matter in the upper layer of it, and lead to an increase in the available nitrogen compounds. These valuable plant foods would in their turn stimulate the vegetative growth of any plants whose roots could obtain access to it, and this is actually what happened.

Another interesting feature was the abundance of nodules on the roots of leguminous plants when planted in a mixture of ash and old soil, and the luxuriant growth made. This would tend to show that the nitrogen-collecting bacteria causing the formation of these nodules were not destroyed in the old soil; or were reintroduced with the planting material that was used, and finding partially sterilized soil, and therefore an absence of enemies, were given the best chance of increasing in numbers. It has been largely due to this fact that planters have been able to obtain such excellent crops, particularly of the pigeon pea, and also to utilize to a considerable degree the heavy growth made by this plant as valuable green dressing material.

So far, it has not been necessary to use to any extent the wild types of plants such as are found covering large areas of devastated land in the leeward district.

To-day, eight years after the last eruption, we see that the vegetation on the mountain slopes, and other places, has largely returned, and that agricultural conditions are almost normal. In the windward district, it is true, much greater progress has been made with agriculture than in the leeward, but the latter presents greater difficulties on account of the hilly nature of the lands; nevertheless the sphere of operations here is continually being extended.

List of Species of Plants Collected During the Year 1907, in the Area Badly Devastated by the Soufriere*.

1. *Argemone mexicana*, L.
2. *Cleome pungens*, Willd.
3. *Polanisia viscosa*, D.C.
4. *Sauvagesia erecta*, L.
5. *Securidaca Lamarcki*, Griseb.
6. *Drymaria cordata*, Willd.
7. *Portulaca oleracea*, L.
8. *Mammea americana*, L.
9. *Freziera hirsuta*, Sm.
10. *Sida carpinifolia*, L.
11. *Urena lobata*, L.
12. *Thespesia populnea*, Corr.
13. *Gossypium barbadense*, L.
14. *Eriodendron anfractuosm*, D.C.
15. *Ochroma Lagopus*, Sw.
16. *Corchorus hirtus*, L.
17. *Corchorus siliquosus*, L.
18. *Stigmaphyllon puberum*, Juss.
19. *Tribulus maximus*, L.
20. *Melia Azedarach*, L.
21. *Vitis sicyoides*, Baker.
22. *Mangifera indica*, L.
23. *Spondias lutea*, L.
24. *Spondias purpurea*, L.
25. *Crotalaria incana*, L.
26. *Crotalaria retusa*, L.
27. *Crotalaria stipularis*, Desv.
28. *Crotalaria verrucosa*, L.
29. *Indigofera Anil*, L.
30. *Tephrosia cinerea*, Pers.
31. *Desmodium incanum*, D.C.
32. *Desmodium tortuosum*, D.C.

32a. *Teramnus* sp. (not determined)

33. *Erythrina Corallodendron*, L.
34. *Phaseolus semierectus*, L.
35. *Vigna vexillata*, Benth.

35a. *Atylosia scarabaeoides* (introduced)

36. *Flemingia strobilifera*, R.Br.
37. *Andira inermis*, H.B.K.
38. *Caesalpinia Bonducella*, Fleming.
39. *Cassia occidentalis*, L.

39a. *Cassia* sp. (not determined)

40. *Tamarindus indica*, L
41. *Mimosa Ceratonia*, L.
42. *Mimosa pudica*, L.
43. *Leucaena glauca*, Benth.

43a. *Inga* sp. (not determined)

44. *Terminalia Catappa*, L.
45. *Quisqualis indica*, L.
46. *Psidium Guyava*, Raddi.
47. *Tibouchina longifolia*, Baill.
48. *Tetrazygia discolor*, D.C.
49. *Clidemia hirta*, D.

49a. *Triconia*, 2 spp. (not determined)

50. *Passiflora foetida*, L.
51. *Passiflora laurifolia*, L.
52. *Carica Papaya*, L.
53. *Momordica Charantia*, L.
54. *Begonia dominicalis*, A.

54a. *Psychotria*, 2 spp. (not determided)

55. *Palicourea crocea*, D.C.
56. *Borreria laevis*, Griseb.
57. *Psychotria* sp. (not determined)
58. *Vernonia arborescens*, Sw.
59. *Elephantopus spicatus*, Aubl.
60. *Eupatorium ossaeanum*, L.
61. *Eupatorium ossaeanum*, D.C.
62. *Mikania hastata*, W.
63. *Erigeron bonariensis*, L.
64. *Pluchea odorata*, Cass.
65. *Wedelia buphthalmoides*, Griseb.
66. *Spilanthes* sp.
67. *Bidens rubifolius*, H.B.K.
68. *Porophyllum ruderale*, Cass.
69. *Emilia sonchifolia*, D.C.
70. *Ageratum conyzoides*, L.
71. *Lobelia* [Tupa] *cirsiifolia*, Lam.
72. *Vinca rosea*, L.

72a. *Vinca rosea*, var. *alba*.

73. *Asclepias curassavica*, L.
74. *Spigelia Anthelmia*, L.
75. *Cordia cylindrostachya*, Roem. et Schult.
76. *Tournefortia bicolor*, Sw.
77. *Heliotropium indicum*, L
78. *Ipomoea biloba*, Forks
79. *Ipomoea cathartica*, Poir.
80. *Ipomoea Quamoclit*, L.
81. *Ipomoea sinuata*, Ort.
82. *Ipomoea umbellata*, Mey.
83. *Ipomoea* sp.
84. *Convolvulus micranthus*, Roem. et Schult.
85. *Solanum bahamense*, L.
86. *Solanum nigrum*, L.
87. *Solanum torvum*, Sw.
88. *Physalis angulata*, L.
89. *Capraria biflora* L
90. *Episcia melittifolia*, Mart.
91. *Besleria lutea*, L.
92. *Sesamum indicum*, L.
93. *Thunbergia fragrans*, Roxb.
94. *Stachytarpheta jamaicensis*, Vahl.
95. *Citharexylum quadrangulare*, Jacq.
96. *Aegiphila martinicensis*, L.
97. *Clerodendron aculeatum*, Griseb.
98. *Hyptis capitata*, Jacq.
99. *Salvia occidentalis*, Sw.

---

*As has been indicated, an account of the Flora of St. Vincent and adjacent islets appears in the *Kew Bulletin*, 1893, p. 231. [Ed. *W.I.B.*]

List of Species of Plants Collected During the Year 1907, in the Area Badly Devastated by the Soufriere—(*Concluded.*)

100. *Boerhaavia paniculata*, Rich.
101. *Iresine celosioides*, L.
102. *Microtea debilis*, Sw.
103. *Phytolacca icosandra*, L.
104. *Coccoloba uvifera*, Jacq.
105. *Piper dilatatum*, Rich.
106. *Euphorbia hypericifolia*, L
107. *Euphorbia pilulifera*, L.
108. *Jatropha gossypifolia*, L.
109. *Croton flavens*, L.
110. *Croton lobatus*, L.
111. *Ricinus communis*, L.
112. *Ficus populnea*, Wild.
113. *Artocarpus incisa*, L.
114. *Cecropia peltata*, L.
115. *Boehmeria ramiflora*, Jacq.
116. *Cyrtopodium Woodfordii*, Lindl.
117. *Habenaria* sp.
118. *Alpinia nutans*, Rosc.
119. *Maranta arundinacea*, L.
120. *Heliconia Bihai*, Sw.
121. *Dioscorea multiflora*, Presl.
122. *Commelina virginica*, L.
123. *Acrocomia lasiospatha*, Mart.
124. *Cyperus rotundus*, L.
125. *Scleria pratensis*, Nees.
126. *Scleria reflexa*, H.B.K.
127. Sedges (4 sp. not determined)
128. *Paspalum conjugatum*, Berg.
129. *Panicum maximum*, Jacq.
130. *Cenchrus echinatus*, L.
131. *Pennisetum setosum* Rich.
132. *Arundinella martinicensis*, Trin.
133. *Ischaemum latifolium*, Kunth.
134. *Cynodon Dactylon*, Pers.
135. *Eleusine aegyptiaca*, Desf.
136. *Eleusine indica*, Goertn.
137. *Gynerium saccharoides*, H.B.K.
138. *Bambusa vulgaris*.
138a. Grasses (three spp. not determined)
139. *Cyathea arborea*, Smith.
140. *Nephrodium molle*, Desv.
141. *Gymnogramme calomelanos*, Kaulf.
141 a & b. (2 species, not determined)
142. *Lycopodium cernuum*, L.
143. *Pogonatum tortile*, P. Beav.
144. *Philonotis tenella*, Jacq.
145. *Stereocaulon* sp.

NOTES ON ST. LUCIA AND ITS AGRICULTURE.

BY J. C. MOORE, Agricultural Superintendent, St. Lucia.

St. Lucia is the most northerly, and also the largest of the group of Islands in the West Indies which form the Colony called the Windward Islands, and is situated in 13° 50′ N. and 60° 58′ W. Long., at a distance of 21 miles to the S.E. of Martinique, 21 N.E. of St. Vincent and about 90 W.N.W. of Barbados. Its greatest length is about 30 miles, its greatest breadth 14 miles, and its superficial area is estimated at about 233 square miles.

The island is mountainous, consisting of a central range of hills about 1,500 feet in height, buttressed by ridges that gradually slope down in all directions to the sea, with numerous narrow and well sheltered and fertile valleys between them.

Geology.

The following notes on the geology of the island are taken from the St. Lucia *Handbook* of 1912 :—

The island may be considered as a confused, amorphous mass of igneous matter, without any definite structural arrangement,

and its rocks, with the exception of a coralline limestone found in the neighbourhood of the town of Soufrière, are all of igneous or volcanic origin. These rocks are either crystalline, of the nature of traps, exhibiting much variety of structure, or uncrystalline, composed of volcanic ashes, constituting tufas. Of the former, many resemble basalt and greenstone, whilst some are an approach to granite or syenite. The mountains are made up of a volcanic conglomerate, and basalt rocks of all sorts (porphyrites, andesites, pumiceous and bedded tuffs), phonolitic and schitose masses; felstones, lavas, and such like are found. These rocks are tertiary or post-tertiary. In the valleys and alluvial plains the soil consists of a deep vegetable mould mixed with clay, and in the more elevated positions, of read earth; the substratum is a mixture of sand and gravel.'

CLIMATE.

The driest season of the year is from February to April, when the nights are pleasantly cool. The rainy season extends from about June to November, thus giving a long season in which planting operations can be carried out. The climate is humid. The annual rainfall ranges from about 40 inches in some of the drier coastal districts to about 150 inches in the more central parts of the island, which contain the most fertile land.

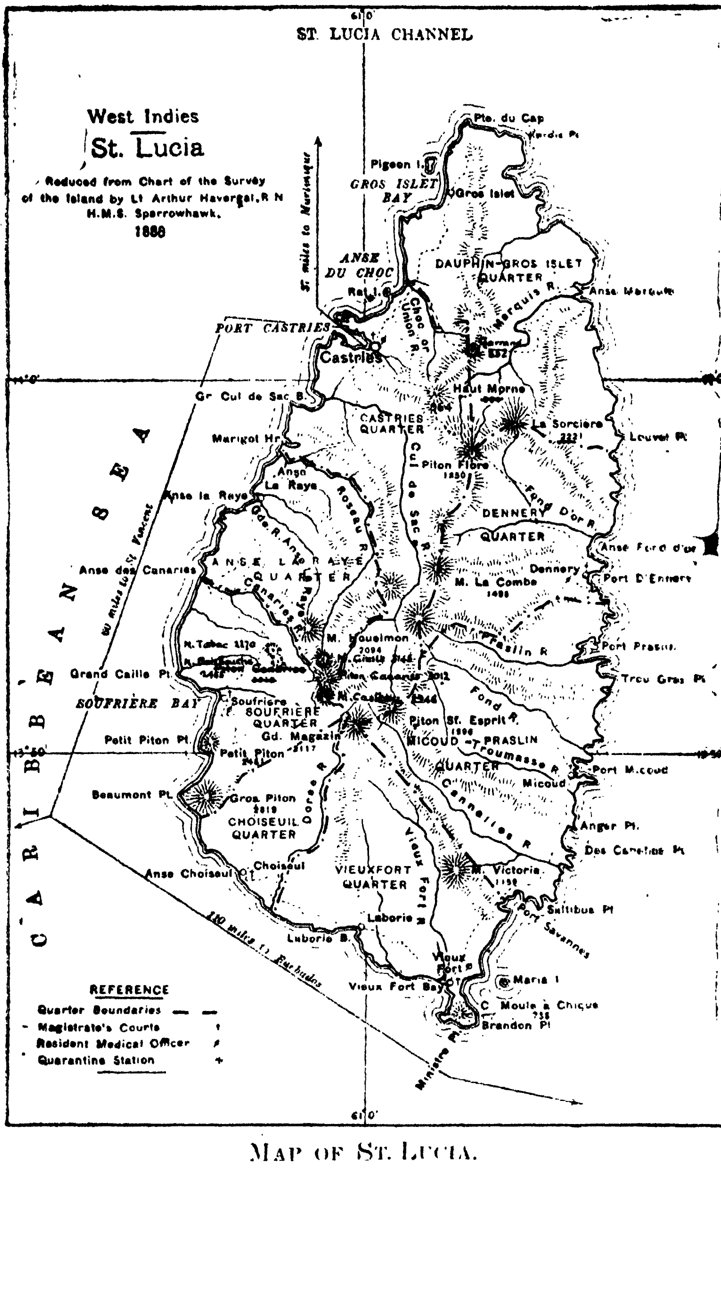
The average temperature is about 79° F., in the shade, the average minimum being about 71° F., and maximum about 87° F.

Accompanying these notes is a map of the island on which is shown the annual rainfall during 1910 in the various districts from which records were received by the Agricultural Department. Although the rainfall for that year was somewhat above the average over the whole island, the figures usefully indicate its distribution. It is probable that the greatest precipitation occurs along the main ridge and in its vicinity, but no records are available.

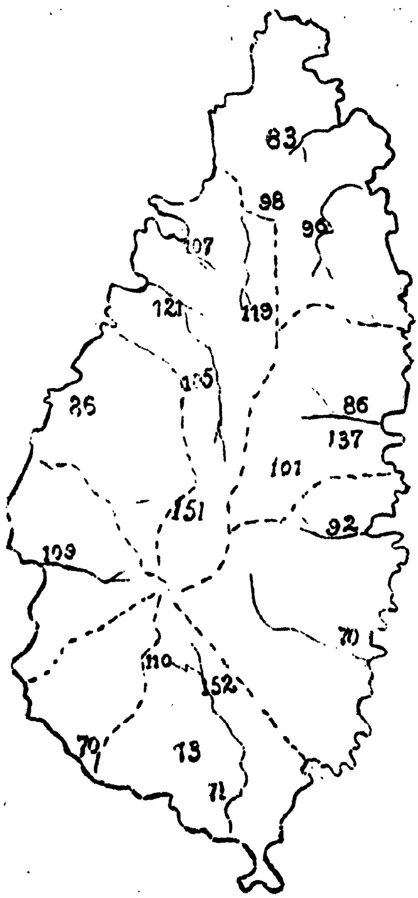
AGRICULTURAL LAND.

The area of flat and gently undulating land suitable for arable tillage is comparatively small, and is for the most part confined to the lower slopes near the coast, and the numerous valleys. The larger areas of flat land consist of very fertile alluvium, stretching back from the sea for 2 or 3 miles, along the courses of the main rivers. The soil in these areas varies in texture from sands to clayey loams, the latter character being most general.

The larger of these valleys—Cul-de-Sac, Roseau, Mabouya, and the flats of Vieux Fort—are chiefly devoted to the cultivation of sugar-cane, there being at each of these centres usines for the production of crystal sugar. The fertility of the soil in these valleys may be gauged from the fact that Bourbon cane has been often ratooned for ten years, and instances are known of this cane being profitably ratooned for sixteen years. Portions of the larger, and many of the numerous small valleys which at one time grew cane only, are now planted in cacao, and in some



MAP OF ST. LUCIA.



SKETCH MAP SHOWING RAINFALL IN DISTRICTS IN ST. LUCIA.

instances, limes. The success attending the cultivation of cacao and limes in these situations is somewhat variable, depending chiefly upon the suitability of the treatment that the trees have received. Generally, the results have been satisfactory. There is however little doubt but that elevations approximating 500 feet are the most suitable for these crops, particularly cacao, given suitable soil, rainfall and protection from wind.

By far the greater portion of the island, particularly the interior, is cut up by innumerable mountains, hills and spurs, irregularly shaped and disposed, many of which are very precipitous and unsuitable for arable cultivation. In consequence, much of the land reposes at angles which render it more suitable for orchard cultivation than for such crops as require frequent tillage and replanting ; for the soil needs the support of permanent roots to resist the tendency to too rapid erosion such as would take place with the rainfall, if it was kept constantly in arable tilth.

The very steep hillsides are unsuitable for any form of cultivation, and should never be denuded of the bush or forest on them, as if they are cleared, they become sources of danger as potential land-slides to destroy or damage underlying plantations. Such steep land, and the tops of the ridges, should be left clothed with their natural vegetation, to provide fertilizing organic matter for the lower slopes, to be gradually carried down to the cultivated land to give protection from wind, and possibly to act as a safeguard against destructive land-slides.

Owing to the very hilly nature of the country, roads for vehicular traffic are not numerous, and with few exceptions are confined to the sections of the main highways ; and these for the most part traverse the coastal lands, and afford communication between the towns and villages of the island. The principal agricultural districts are linked up with the main roads and seaboard by by-roads which are kept in a suitable condition for riding. The produce of many of the districts served with these by-roads has to be transported by heading, or on the backs of mules and donkeys, to the nearest shipping bay, or port of call of the daily coasting steamer which plies along the leeward coast. On the windward side of the island, produce is shipped by sailing vessels to Roseau, the capital, which is a very important shipping port and coaling station. As ships carrying cargo come alongside the wharves, produce is quickly and safely handled between them and the warehouses close by ; there are none of the risks attending the transference of cargo in lighters.

Crown Lands.

There are thousands of acres of Crown Land, from which selections may be made for the cultivation of cacao, limes, oranges, rubber, grape fruit, Liberian coffee, cola nuts, etc. These lands are sold at the low price of £1 per acre, payable in five annual instalments, in addition to the cost of surveying, which varies according to the area surveyed. On 200 acres, the cost of surveying would be about £36. A discount of 20 per cent. is allowed on cash payments on large areas of land purchased from the Crown. These lands are for the most part situated in the interior of the island, extending centrally from the Castries

quarter in the north, to the heights of Laborie and Vieux Fort in the south, being distant from the windward and leeward coasts some 4 to 6 miles. A plan of the island is given showing the position of the Crown lands The area indicated includes the land that has been alienated, the watershed reserved over 1,000 feet elevation along the main ridge, and the lands still available for settlement.

RETURN OF CROWN LANDS ALIENATED IN ST. LUCIA DURING THE FIVE YEARS 1906-10.

District.	YEAR.					Total.
	1906	1907	1908	1909	1910	
	a. r. p.	a. r. p.	a. r. p.	a. r. p.	a. r. p.	a. r. p.
Castries	192 1 6	Nil.	18 0 3	127 0 01	781 0 29	1118 3 29
Dauphin	88 2 13	135 3 28	77 3 32	55 1 25	64 0 32	416 3 39
Dennery	265 2 11	79 3 27	49 1 39	45 3 09	51 1 23	492 0 29
Praslin	86 1 13	6 0 00	6 0 00	10 1 07	8 3 21	117 2 02
Micoud	251 0 28	26 2 32	17 2 10	70 1 01	11.1 08	376 3 39
Vieux Fort	32 0 28	45 1 12	24 3 8	574 1 25	62 0 20	738 3 05
Anse-la-Raye	285 1 27	48 1 03	58 3 07	261 1 15	62 3 19	717 2 31

Total area alienated 3,979 ac. 0r. 14p.

Since 1906, about 33 miles of by-roads have been constructed, some of which pass through districts more or less cultivated; while others, notably Raillon, Vollet, and Errard Extension on the windward side, and the Ravine Souffre, Millet, and Canaries Valley roads on the leeward side of the island, pass through, or lead to, Crown lands that are only partly settled. Another by-road to the Crown lands recently opened up in the Vieux Fort heights is about to be made. Practically nothing is known of the most central portion of the interior; but it is evident that the land is in dense forest, well watered, and quite as variable in configuration, and probably in soil character, as the surrounding lands which are better known. The Agricultural Superintendent has visited several of the districts recently opened up by new roads, and the results of the observations made are as follows:—

WINDWARD SIDE OF THE ISLAND: RAILLON ROAD.

This road serves land in the Dennery Quarter, bordering with the Micoud Quarter, and starts from a point on the main coastal road, near the mouth of Praslin River.

It passes for about 4¾ miles inland, through gradually rising land, which is partly in high woods and partly in small holdings on which provision gardens and some young cacao are being established. There are also a number of holdings on which small areas of bearing cacao—apparently from three to seven years old—are to be found. On greyish, light soil, with a soil shrinkage* of 6 per cent., cacao trees, five to six years old, were quite healthy and very promising; while on soil with a shrinkage of 14 per cent. young cacao trees had died out when about 8 feet high. The colour of the subsoil in this instance was red. The land along the direction of the road is very variable in texture; soil samples taken at intervals showed shrinkages of 6, 13, 16, and 17 per cent. The colour of the subsoils giving the higher shrinkage results was terra-cotta red when they were dry.

Although the land along the higher reaches of this road is inclined to be heavy, better land suitable for cacao and limes is likely to be found on the lower slopes on either side of the du Rocher ridge, and along the banks of the Praslin and Fond Rivers. In the heights of the Fond valley, some excellent land is reported to have been opened up for cacao.

Branching off from the main road at a point about a mile to the north of the village of Micoud, the Vollet road passes up the valley of the same name, and then as it approaches Grenoville it crosses over a ridge into the Troumassée valley and opens up the land on the heights of Micoud.

The road extends for a distance of 4 miles inland. For the first mile or two the land is rather shallow and poor, and where it is cultivated it is chiefly planted in cassava and potatoes. It gradually improves in depth and quality as the Crown lands are approached. These begin at Grenoville, at an altitude of about 800 feet. The soil here is comparatively light, and appears to be fertile. Shrinkage tests gave 8 and 6 per cent. Further inland, at Lartique, at an altitude of about 900 feet, the soil is much the same in character, giving 10 and 6 per cent. shrinkage. A few patches of very promising cacao occur along the route, and indicate the suitability of the soil for this crop. Beyond the end of the road, at Mahoe, several acres of excellent cacao are established. The trees are about eight years old, some of them being on alluvium near the Troumassée River, and others on gently sloping land and steeper hillsides. Although the plantations could be improved by deeper drains and some reduction of shade, the general condition and progress of the trees indicate the suitability of the soil and environment for the growth of cacao. The subsoil under this cacao gave a shrinkage of 12 per cent., and the surface soil one of 6 per cent. Peasant proprietors in this locality stated that equally good, and even better, soil is to be found farther inland. The general appearance of the soil in this locality impresses one very favourably as to its suitability for cacao or limes. The growth of limes planted in the bottoms of land located near the sea at several places along the wind-

*It may be useful to state here, that information concerning soil shrinkage appears in another part of this issue of the *West Indian Bulletin.* [Ed., *W.I.B.*]

ward coast has been carefully observed, and the conclusion arrived at is to the effect that these trees thrive well in these situations if the soil is not too heavy and is thoroughly drained, provided that the trees receive proper cultivation and care. Where drainage was defective or wanting, the trees were invariably dwarfed, showed signs of disease, and generally were not thriving, as could only be expected.

SOUTHERN AND LEEWARD SIDE.

The heights of Vieux Fort are in the more northern portion of that Quarter, and are reached at present by rough tracks branching from by-roads in the districts. A new by-road to some of the lands situated here is in course of construction. The land here, recently opened up for cacao, is in the neighbourhood of the sources of the Vieux Fort River. In the heights of Vieux Fort some excellent land has during the past three or four years been opened up, and the planting of cacao is being pushed forward. The land, as is usual in St. Lucia, is variable, but there appear to be considerable areas of soil in this locality suitable for cacao and limes. Much of the more accessible land has already been applied for, and a hundred or more acres planted in cacao. Very good cacao, bearing a few pods at two and a half years from planting, and of very promising appearance, is to be seen on soil giving a shrinkage of 5 per cent. On this soil the benefit of a carefully planned drainage system has been very noticeable in the remarkable growth of the trees since the drains were made, as compared with their previous progress. Samples of soil taken from this district, and submitted to shrinkage tests, gave the following results:—5, 12, 1, 13, and 6 per cent. The Crown lands in the Canaries district are located 3 to 4 miles inland, around the borders of the Anse-la-Raye and Soufrière Quarters.

In 1909, the Agricultural Instructor inspected these and reported that there was some very good land there, suitable for cacao. Soil samples from the forest land at Houlemon (1,200 feet) gave shrinkage tests of 6 and 8 per cent., and from Roblot (700 feet) 6 per cent. The colours of the dried samples were fawn, stone, and light-brown, respectively.

The Crown lands opened up by the Millet road, which traverses the heights of Roseau and Millet, to the west of the Roseau River, while varying considerably as regards the texture of the soil, show a tendency to approach the lighter, rather than the heavier, type. There is good cacao in this locality, but much of it would repay improved cultivation. On some of the more recently cleared land, cacao planted in 1907, on soil with a shrinkage of 9 per cent., is now bearing, and is very healthy and robust; while a small patch of trees in the same field, but on soil with a shrinkage of 16 per cent., was failing in 1910, and has shown little improvement since. What slight improvement appears is noticeable only on the outer edges of the patch, where the soil gradually becomes lighter. The rainfall in this locality in 1910 was 151 inches.

In correspondence dated January 30, 1911, from Sir Daniel Morris, K.C.M.G., to the Under Secretary of State for the Colonies, and having reference to the forest lands of St. Lucia, men-

SKETCH MAP SHOWING EXTENT OF CROWN LANDS IN ST. LUCIA.

[See p. 35.]

Crown Lands shown by Interior areas.bounded by Thicker Lines.

SKETCH MAP SHOWING AREAS IN SUGAR-CANE, CACAO, AND LIMES, IN ST. LUCIA.

[See p. 40.]

Areas in Sugar-Cane	Designated	by	means	of	Vertical Lines.
,, ,, Cacao	,,	,,	,,		Horizontal ,,
,, ,, Limes	,,	,,	,,		Dots

tion is made of the unsuitability, for permanent cultivation, of certain stiff impervious yellow clays, such as are to be found on the Bara-Bara pass and along the Gouldsworthy road. Samples of soil of the above description have been obtained from the Bara-Bara road, which connects the village of Dennery with Castries, and have been subjected to shrinkage determinations, with the following results. Sample No. 114, taken from about half way up the eastern slope, gave a shrinkage of 7 per cent.; the soil was salmon-coloured when dry. Sample No. 115, from about three-quarters of the distance up the same slope was of the same colour and tested 14 per cent. On the western side, descending toward Castries, sample No. 116, taken about 200 yards from the water spring, tested 12 per cent.; and was of a buff tint in colour. Lower down, near the first clearing on the south side of the road, the soil for a short distance is of a light buff colour, and more sticky than that in any other part examined. The sample from this place gave a shrinkage of 16 per cent. The last-mentioned sample was taken from the top of the ridge into which the road was cut.

The coolie settlement at Forestière is situated in this localitys at a distance of 4 to 5 miles from Castries. On the higher land, of the settlement, practically no permanent cultivation exists. Lower on the hillsides, it is probable that much of the surface soil has been washed away from the steeper slopes, through defective methods of cultivation and the absence of suitable drains. The cacao in this locality is mostly planted on the lower slopes, and in the small ravines, which are fairly numerous. Where the surface soil is comparatively light and contains a good supply of vegetable matter, the cacao grows well, but there are plots which have the appearance of having lost much of the surface soil, and the land is apparently too heavy for the successful growing of cacao. Where the soil is of the heavier type, and hard on the surface, the cacao trees are less vigorous and appear to be more subject to diseases than trees on the lighter soils, which occur here and there on the lower slopes of the settlement. It is in this locality that most of the banana disease has been observed by the Officers of the Agricultural Department, and it may be due largely to the heavy character of the soil, together with the heavy rainfall of the district, and the absence of thorough drainage, that this disease has become more common here than elsewhere

To summarize in a general way, it may be said that the soils of St. Lucia, as a whole, are very fertile, and that their texture is clayey rather than sandy in quality.

Their variation, often within narrow limits, in colour, texture and depth, as well as their exposure and angle of repose, is so marked and general that it is not possible to refer to any particular district as possessing a distinct type of soil. Broadly speaking, the ratio of light to heavy types is greater in the southern than in the northern half of the island. The soil samples referred to in these notes were taken at a depth of about 20 inches in the subsoil, except where it is otherwise stated.

Principal Agricultural Industries.

Sugar. Sugar is the principal product of export, though it is now followed very closely by cacao in export value.

The cultivation of the sugar-cane occupies at present about 3,000 acres, the major portion of which is worked in connexion with central factories owned by private companies. There are four such factories turning out good grades of usine sugar ; these are situated in the valleys of Mabouya, Cul-de-sac, Roseau, and Vieux Fort. The position of the principal sugar-growing districts are shown in one of the accompanying maps of the Colony.

The quantity, in round figures, of sugar, molasses, and rum exported during the last five years is given in the following table :—

	Usine sugar, tons.	Muscovado sugar, tons.	Molasses. casks.	Rum, gallons.
1906	5,441	230	313	6,276
1907	5,302	62	49	3,263
1908	4,881	101	60	23,440
1909	5,365	160	60,099 galls.	27,883
1910	5,199	76	95,220 „	4,692

Several of the muscovado estates are again producing sugar, as the result of the improvement in prices during the last year or two. On the large estates the Bourbon cane is gradually giving place to approved seedling canes, notably B. 208, B. 147, B. 1753, B. 6450, B. 3412 and D. 625.

A large number of plants of these canes have been propagated and distributed by the Department of Agriculture, and large direct importations have been made by the factories. There is ample room for extension of the area under sugar-cane, and cane-farming on a co-operative system would probably be worth the attention of the capitalist.

Cacao. Cacao forms the second large item of export. The following statistics relative to the cacao produced in the island, during the twenty years ended 1910, are based upon the Blue Book export returns.

The following figures indicate that during the period under review, the greatest activity in cacao-planting occurred during the first decade. During the second decade the increase that took place was due partly to the additional area planted, and partly to the improved methods of cultivation followed on many estates, and adopted chiefly as the result of the experiments in cacao cultivation and manuring carried out by the Agricultural Department in various parts of the island. Similar improvement in the peasants' cacao has not been general, and it is probable that the number of instances, in which this class of cacao has become more productive as the result of better cultivation, are so few as to produce no appreciable contribution to the increase of the total exports.

Year.	Bags of 200 lb.	Bags of 200 lb. Annual average for five-year periods.	Percentage of increase over output for the first five years.
1891	4,941		
1892	4,381		
1893	5,188		
1894	4,916		
1895	3,481	4,581	...
1896	5,334		
1897	4,402		
1898	4,713		
1899	4,411		
1900	6,490	5,070	10·6
1901	3,285		
1902	7,466		
1903	8,571		
1904	6,679		
1905	9,468	7,094	54·8
1906	7,754		
1907	8,598		
1908	6,775		
1909	10,855		
1910	8,187	8,434	84·0

Taking the average yield of cured cacao throughout the island to be 1½ bags per acre, the indicated acreage based on last year's output is 5,458; and it is probable that the area of young and non-bearing trees is sufficient to bring the total area of land planted in cacao within the neighbourhood of 6,000 acres.

The principal cacao-growing areas are indicated on an accompanying map, from which it will be observed that the cultivation is well distributed over the island, though it occupies but a small portion of the available area. While the yield of cured cacao from the numerous and often badly worked small plantations owned by peasants is probably, on the average, as low as one bag per acre, many of the large estates that are cultivated give crops averaging from 3 to 5 bags (of 200 lb. each) per acre, the output varying generally with the thoroughness and suitability of the cultivation given. In addition to the advancement made during the past few years in cultural methods, there is on the large estates a growing recognition of the importance of controlling by suitable means the pests and diseases to which the trees are subject. The preparation of the cured product for market is a matter which has also shown marked improvement, particularly the development of uniformity in the final colour and polish of the bean. A cacao-polishing machine, invented by a local planter, Mr. George Barnard, has proved to be thoroughly practical, and St. Lucia cacao prepared by it has gained prices equal to those of the finest Grenada qualities. It is probable that this machine will displace the ordinary 'dancing' process

on the larger estates, in the near future. The diseases common to cacao in the West Indies are present in St. Lucia. The most common is the pod rot, and canker of the stem and branches, caused by *Phytophthora Faberi*. The pod rot occurs everywhere on cacao, and varies in the severity of attack very considerably with the degree of humidity prevailing when the pods are forming. It is a matter of common observation among planters that a prolonged period of heavy rains is accompanied by an increase in the number of pods damaged by this fungus. The destruction of empty shells is practised on some estates, apparently with good results, but no careful experimentation to determine the real value of such precautionary measures has been conducted locally. The importance of measures to control this fungus, now it is known to cause the common canker of cacao, is greatly increased, and this is being emphasized by the Agricultural Officers whenever possible. The pink disease (*Corticium lilacino-fuscum*) has occurred in one or two places during the last few years, but this is at present not general, and can be controlled by suitable measures.

The die-back and stem disease caused by *Thyridaria tarda** is found in most of the cacao districts, but is generally most troublesome where the trees are in bad health from other causes, and past experiments have shown that high cultivation is probably the best treatment for combating it.

The root disease, which attacks cacao and many other trees of economic importance, has given considerable trouble on some estates, notably in the Etangs district at Soufrèire. It has been known and recognized amongst cacao for the past ten years, and the increased interest in diseases that has resulted from the information spread by the Imperial Department of Agriculture has no doubt been largely responsible for bringing this disease under more frequent notice, especially as it is one which is seldom discovered by the ordinary observer until it has become well established, and then its presence is revealed by the sudden death of one or more trees. Although the actual loss through root disease is not so wide-spread nor as great, in the aggregate, as that from the pod rot, it is, nevertheless, capable of doing serious damage, attacking as it does the most vital part of the tree, and being one of the most difficult to contend with on account of its subterranean character. The recommendations of the Department for dealing with the disease have been carried out with varying degrees of success in different parts of the island; where this has been done in a thorough manner, its spread has certainly been checked.

Limes. The cultivation of limes on a commercial scale began in 1901, and steady progress has since been made. It is estimated that the total area under this cultivation is about 800 acres. The trees range in age from one to eleven years, and the plantations are on land situated at various altitudes, ranging from sea-level to about 1,000 feet, but the greater number of them are on alluvial soil.

* This fungus was formerly known as *Diplodia cacaoicola* and *Lasiodiplodia* sp. in the publications of this Department, while more recently it has been referred to there as *Lasiodiplodia theobromae*. [Ed., W.I.B.]

The localities of the lime plantations are shown on an accompanying map. Where the soil is light and naturally well drained, and of sufficient depth, and the rainfall approximates to 80 inches per annum, the trees thrive and develop remarkably well, frequently beginning to produce fruits about the third or fourth year. On the other hand, where the soil is of the heavier type, although other conditions may be favourable, the development of the trees is not as rapid or uniform, and they appear to be more subject to root troubles and scale insect pests, particularly where attention has not been given to the proper drainage of the land.

The first record in the Blue Book of the Colony, of lime products exported, occurred in the year 1906, when green limes to the value of £99 18*s.* 6*d.*, and lime juice valued at £27 were shipped. The official records of lime exports are as follows :—

Year.	Green limes, value.			Juice, value.			Total value.		
	£	s.	d.	£	s.	d.	£	s.	d.
1906	99	18	6	27	0	0	126	18	6
1907	111	4	6	81	0	0	192	4	6
1908	76	9	2	125	12	4	202	1	6
1909	31	13	0	297	9	0	328	13	0
1910	13	18	6	319	10	0	333	8	6
	333	3	8	850	2	4	1,183	6	0

The method of concentrating lime juice that is favoured on estates having an appreciable area of limes, and on which works have been put up, or are in course of construction, is that of heating by steam in wooden vats. The first small factory erected in St. Lucia was of this type, and, I believe, the first of its kind in the West Indies. The mill has granite rollers, is steam driven, and the juice is boiled in wooden vats, in the bottom of each of which is fitted a copper steam coil. Coils of heavily tinned copper, or preferably of block tin, are recommended as being most suitable, as they are less subject to the action of the acid, and consequently a purer juice is obtained

It is suggested that the modern factory on an estate of 60 or more acres of limes might, to advantage, be equipped at the outset with plant that could readily be turned to account for the production of pure articles in the form of raw or concentrated juice, or citrate of lime, so as to be able to produce whichever is in most profitable demand.

Insect pests of limes are present in the form of scale insects, as they are in all citrus-growing countries; and while they may be found, if searched for, in all the plantations that the writer has

visited, they do not occur to such an extent as to constitute a serious menace to the lime industry, nor do they appear likely to do so where the soil and climatic conditions are suitable for the growth of the trees, and if ordinary precautions are observed.

Practically all the kinds of scale that have as yet been observed to attack our lime trees are parasitized by various fungi, and these are doing good work in controlling the pests.

A fungoid disease attacking the roots of the lime tree has caused the loss of a few trees on several plantations, and is under investigation.

A more complete account of the lime industry is given in a memorandum on the subject recently prepared by the Agricultural Superintendent and submitted to the Imperial Commissioner of Agriculture.*

In conclusion, I have to, acknowledge the assistance that I have received from the Colonial Engineer in preparing the information respecting the Crown lands, and in the colouring of the originals of the maps to show their position in the island.

THE LIME INDUSTRY IN ST. LUCIA.

BY J. C. MOORE,

Agricultural Superintendent, St. Lucia.

COMMENCEMENT AND PROGRESS.

The first attempt to plant limes on a commercial scale in St. Lucia was made in the year 1901, on what was formerly a sugar estate, situated in a fertile valley on the windward coast. During that year and the following, 22,112 lime plants were supplied for this estate by the Agricultural Department. From this, the pioneer lime plantation, there was exported about five years later the first concentrated juice produced in the island.

Apparently, no further work in connexion with planting in other parts of the island was done until 1905, when other landowners, doubtless encouraged by the promising results of the first venture, began seriously to contemplate planting their lands which appeared suitable for the crop. Since 1905, the demand for lime plants from the nurseries of the Agricultural Department has been steady, the total number distributed from April 1901 to March 1911, being 257,907, representing an average annual distribution of 25,791 plants.

The progress of the industry may also be indicated by recounting the number of estates on which limes have been planted, as given by the plant distribution records of the Agricultural Department. From 1901 to 1905 there was only

* This is reproduced in the article which follows. [Ed., *W.I.B.*]

one estate on which limes were grown. In 1905 there were 4; 1906, 11; 1907, 19; 1908, 24; 1909, 30; 1910, 42. On some of these, however, the limes occupy only a few acres, while on others the acreage ranges from 30 to 70. It it estimated that the total area under limes at the beginning of 1911 approximated to 800 acres. The trees range in age from one to nine years.

Although the industry is still in its infancy, it may be regarded as having gone far toward becoming established, and there are indications that in the near future it will rank third in importance in the agriculture of the Colony.

Soil.

The plantations are on land situated at various altitudes, ranging from sea-level to about 1,000 feet. The soil, also, varies considerably in character, from sandy soils to heavy loams. The greater number of the plantations are on alluvial soil. Where this is light, and naturally well drained and of sufficient depth, and the rainfall approximates to 80 inches per annum, the trees thrive and develop remarkably well; and frequently begin to produce fruit about the third or fourth year. On the other hand, where the soil is of the heavier type, although other conditions may be favourable, the growth of the trees is not as rapid or uniform, and they appear to be more subject to root troubles and scale insect pests; particularly where attention has not been given to the proper drainage of the land.

The Necessity for Drainage.

Observations made during the past four years on the progress of trees in various parts of the island, and under varying conditions of soil and treatment, have convinced me that the question of drainage is one of the most important points requiring careful and timely attention in cultivating limes on most of the soils, the general character of which more frequently approaches a clayey than a sandy quality. Other cultural operations, such as soil tillage, weeding, spraying and pruning—important as they are—will not take the place of drainage, and their value in aiding in the healthy development of the trees is considerably discounted if the soil does not readily part with its excess water.

The importance of providing an adequate drainage system in a soil possessing high water-retaining properties and no natural, free subsoil drainage, and in which limes are to be planted, cannot be too strongly emphasized. A case in point came under recent observation, where three to four year old trees on rather heavy alluvial soil were seriously attacked by the snow scale, on the stems and branches, the leaves of which were turning yellow. Examination of the drains showed that they had been silted up by floods some months previously, and had not been re-opened. In the course of a few weeks after the drains had been cleaned and deepened, the trees began to recover their normal colour and to show general improvement.

The fact that limes will grow in certain soils and situations unsuited for cacao is recognized by those who are taking up

lime-growing; and it is probable that there is a considerable quantity of land in St. Lucia which, though unsuited for cacao, may grow limes profitably; but there is a danger of this adaptability of the lime being over-rated, with the result that limes are sometimes planted in land because it will not grow cacao, and without sufficient regard to the requirements of the trees. Experiments will no doubt prevent this mistake from being made, in cases in which proper advice has not been sought, and will probably show that the nearer the soil for limes approaches in character what is locally recognized as cacao soil, the more successful will be their cultivation.

Raising Plants.

In raising nursery stock, November has been found to be about the best month of the year for sowing the seed in nursery beds on land near sea-level, as the young seedlings meet with less excessive rainfall and do not exhibit such a tendency to damp off as they have shown when they are sown during, or just before, the rainy season. Sown in November and transplanted in February, when 4 to 6 inches high, they make strong plants, for planting out in their permanent places, by the following August, provided that they are growing in suitable soil, and receive careful attention. The Department has distributed such plants as these at the nominal charge of *6d.* per 100, delivered in Castries, 4 miles from the nurseries. Practically all demands for plants have been promptly met, in spite of the fact that with few exceptions the plants were but rarely ordered until they were required for planting out. Those who have been successful in raising their own plants recognize the advantage of having their nursery stock near at hand, and this method of providing for future planting is likely to be extended; it is to be recommended as the most practical course.

Insect Pests and Their Control.

These are present in the form of scale insects, as is the case in all citrus-growing countries, and while they may be found, if searched for, in all the plantations visited by the writer, they do not occur to such an extent as to constitute a serious menace to the lime industry, nor do they appear likely to do so where the soil and climatic conditions are suitable for the growth of the trees, and if ordinary precautions are observed. Such precautions would include providing a suitable spraying outfit, which could be used to advantage in checking the spread of the pests when, as frequently happens, they occur only on a few plants or trees throughout an otherwise healthy and clean plantation; maintaining the trees in as vigorous a condition as possible, for those which are starved and unhealthy through neglect or uncongenial soil conditions are most susceptible to scale insect attacks; and encouraging the spread of those fungi which have recently been discovered to be parasitic on several of the most troublesome scale insect pests in the West Indies.

The scales most common on lime trees here, as far as observations have indicated, are: The orange mussel scale, (*Lepidosaphes beckii* [Mytilaspis citricola]), orange snow scale (*Chionaspis citri*), West Indian red scale (*Selenaspidus* [Aspidiotus] *articulatus*) and the green scale (*Coccus viridis* [Lecanium viride]). These are also known, respectively, as the purple, white, red, and green scales. Of these four, the purple and white scales are the most common. The red scale occurs most frequently on the upper surfaces of the leaves; the purple scale attacks the stem, branches and leaves—chiefly the under side of the latter; the snow scale occurs mainly on the stem and branches; and the green scale appears to prefer the young leaves and shoots. The fungi that have been observed to be parasitic on these scales are: the red-headed fungus (*Sphaerostilbe coccophila*, Tul.), attacking the purple, red and white scales; the black-headed fungus (*Myriangium Duriaei*, Mont.), on the purple and white scales; and the shield scale fungus (*Cephalosporium lecanii*, Zimm.), attacking the green scale. The writer has found one or more of these useful fungi in every lime plantation visited by him, and it is his opinion that closer observation will show that they are to be found wherever limes are grown in the island. They will doubtless play an important part in controlling the spread of scale insects and the severity of their attacks. As an instance of the effectiveness of these fungi, the writer recently observed, in a plantation of two-year-old trees, the red scale was present in such small numbers as to be discovered only by careful inspection of each tree, and yet in practically every instance the scales were parasitized by the red-headed fungus. The plantation was located in a very humid valley.

The spraying outfit which has been found to answer all purposes while the trees are still small, say up to the third year, is the Success Knapsack sprayer, which can be used either as a knapsack or bucket pump. For more extensive operations with older trees, a more powerful pump is required, and one that can be readily transported over rough ground, open drains and hill sides. The spray pumps of the Fruitall, Pomona and similar types give sufficient pressure for working two leads of hose, and are quite suitable for ordinary orchard work. The ordinary Fruitall outfit on wheels, is however, of little use for moving about the rough and hilly ground on which limes are generally grown here. The writer has devised, to meet local conditions, a handy outfit which can be transported with comparative ease over sloping or rough ground, across open drains, between closely planted trees, and in other places where it would be impossible to take a machine on wheels. This outfit consists of a Fruitall pump clamped into an ordinary beef barrel of 12½ gallons capacity, which is gripped by an iron cradle provided with sockets on opposite sides for receiving two light poles by which the outfit is carried stretcher-fashion by two men. The pump is attached to the barrel by four thumbscrews; the barrel can be detached from the cradle by unscrewing a single nut; and when it is not in use, or during transport, the hose can be conveniently coiled round the stretcher poles. The outfit has been tried, and promises to be very useful

for the purpose for which it is intended, but it might be further improved by using a shorter barrelled pump than the Fruitall. As a precautionary measure, the Botanic Station has been well equipped with spraying apparatus, so that every facility should be given to planters to become acquainted with the working of these machines, and that there should be opportunities of testing the usefulness of spraying, should occasion arise for this method of controlling scale pests to be put into practice.

EXPORTS OF LIME PRODUCTS.

The reader is referred, for these, to the table on p. 43, in the preceding article.

The green limes were mostly shipped from the windward coast, and realized good prices, as much as 3*s*. 9*d*. per box of 200 in the London market, and 14*s*. 2*d*. per barrel of about 1,200 in the New York market, being obtained. The difficulty of securing prompt sloop connexion between the windward coast and steamers arriving at Port Castries appears to have checked the development of green lime exports, but it is probable that the trade will make further progress when the plantations on the leeward coast—which is served by a daily coasting steamer—are more advanced. The first small shipment of concentrated juice was made in 1907. In 1910, the value of all juice exported was £319 10*s*.—a comparatively small amount; but new industries often have a small beginning, and there are encouraging indications that there will be an appreciable increase in production during the next year or two.

CONCENTRATING THE JUICE.

The method favoured on estates having an appreciable area of limes, and on which works have been put up, or are in course of construction, is that of concentrating by steam in wooden vats. The first small factory erected in St. Lucia was of this type, and was, I believe, the first of its kind in the West Indies. The mill has granite rollers, is steam driven, and the juice is boiled in wooden vats, in the bottom of each of which is fitted a copper steam coil. Coils of heavily tinned copper, or preferably of block tin, are recommended as being most suitable, as they are less subject to the action of the acid, and consequently, a purer juice is obtained.

It is suggested that the modern factory on an estate of 60 or more acres of limes might be equipped to advantage, at the outset, with plant that could readily be turned to account for the production of pure articles in the form of raw or concentrated juice, or citrate of lime, so as to be able to produce whichever article was in the most profitable demand.

The installation in a new factory of a steam concentrating plant as a beginning, would, in addition to making it possible to produce a superior class of concentrated juice, admit of a change to citrate manufacture being readily adopted, by the addition of one or more neutralizing vats and facilities for drying the citrate It might be possible to devise some form of steam drier for the

citrate, and thus to utilize further the steam-heating plant; but to what extent this would be possible or practicable the writer is unable to say. The suggestion is merely made for what it is worth. Again, by substituting granite for iron rollers, and earthenware juice pump and pipe connexions for metal ones, the purest raw juice for beverages could be turned out, as desired. The following are mentioned as possible advantages attending the concentration of juice by steam in conjunction with the use of non-metallic rollers and vat connexions, in a well arranged factory:—

(1) The loss of acid by combining with metal would be reduced to a minimum, and a purer sample of juice would be obtained.

(2) There would be a smaller destruction of acid, during concentration, through the use of excessive heat.

(3) The possibility of reaching a higher degree of concentration without the serious destruction of acid which is unavoidable with the direct firing method.

(4) The heating, boiling, frothing, and general handling of the hot juice in a well arranged factory is likely to be under more perfect control than is possible under the old methods; and the works could be more efficiently controlled, and greater cleanliness maintained.

(5) The heating value per unit of fuel used in the steam concentrating method, as compared with the similar value of that employed in direct firing is also a question worth attention when the two systems of manufacture are being compared.

(6) I have not yet had the opportunity of studying the relative labour requirements of the two systems, but am of the opinion that the steam concentrating will prove to be the more economical in this direction.

THE ESTIMATION OF CERTAIN PHYSICAL PROPERTIES OF SOIL.

THE MEASUREMENT OF SHRINKAGE IN SOILS AND ITS APPLICATION IN AGRICULTURE.

(Compiled from the work of various investigators by
GILBERT AUCHINLECK, B.Sc., F.C.S.,
Superintendent of Agriculture, Grenada.)

Work on the estimation of shrinkage of soils was begun in the Government Laboratory for the Leeward Islands some years ago, at the instigation of Dr. Francis Watts, who was at that time Superintendent of Agriculture in the Colony, and has been continued by various investigators in the other islands. All the results available up to date have been collected, and this paper may be regarded as an attempt to co-ordinate and present in a useful form, information which has been obtained by the various investigators. The names of those who carried out the work of investigation and who have kindly supplied their results for compilation are as follows:—

In Antigua, Messrs H. A. Tempany, G. G. Auchinleck and J. L. E. R. Lake; in Dominica, Messrs J. Sowray, Archibald Brooks and Walker; in St. Lucia, Mr. Thomas Worm, and in Grenada, Mr. Norbert Paterson.

AIMS OF THE INVESTIGATIONS.

Before proceeding with the details of the work, it will be well to state briefly its aims, to have a clear idea as to the meaning which underlies the experiments, and to explain what results of use in practical agriculture are to be expected. For the present purpose, we may regard a soil as a collection of a very large number of particles, ranging in size from those of the order of gravel down to those of microscopic dimensions, and we readily realize that the ease or difficulty with which a soil may be worked depends to a large extent upon the proportions in which the particles of various sizes are present. On further consideration we see that lightness of soil is destroyed by the presence of an excess of minute particles; it must be remembered, nevertheless, that clay soils are desirable for some crops. One obvious reason for this is that a multitude of small particles must of necessity pack more closely and intimately than the same number of coarser grains, and we should consequently expect them to be less easily separated and more easily to reset when once they have been separated.

Closely associated with the 'working' properties of soils is the proportion of very fine particles; this grade is usually known as colloidal clay, and it imparts to the soil several peculiar properties which are not of necessity associated in the uninitiated mind with mere fineness. Colloidal clay does not only pack closely—a feature which depends solely upon size, and of itself

would hardly cause much trouble to the planter—but it lends to the soil other properties, the most important of which are:—

(1) Tenacity in holding water,
(2) Setting hard on drying,
(3) Shrinkage and cracking on drying.

These follow from the purely colloidal characters of clay, and an estimation of the proportion of colloidal clay in a soil should be a valuable index to the 'working' properties, while inversely, measurement of any one character, such as shrinkage, should give results which are directly dependent on the proportion of colloidal clay.

The assumptions upon which Dr. Watts based the investigation were that as a moistened mass of soil in a plastic condition may be regarded as being composed of a number of solid particles each surrounded by a shell of water, and that as the particles become smaller the thickness of the water-shell becomes relatively greater in comparison with the diameter of the particles. On this hypothesis, seeing that the particles in clay are extremely small, the water-shells surrounding the solid particles in a mass of clay in a plastic condition would be relatively thick, and consequently, on drying, the mass would shrink greatly; whereas in a sandy soil the solid particles would be larger and the water-shells relatively thinner, so that there would be a smaller shrinking on drying.

The assumption was made that in masses of soil so moistened as to be equally plastic, the conditions, as regards the thickness of the water-shells, would probably be fairly comparable.

On these grounds it was thought that, by measuring the shrinking upon drying experienced by masses of soil of similar plasticity, some approximate relative measure of the average size of the solid particles would be obtained; that clay soils would show large, and sandy soils small shrinkages; and that by this simple means it may be possible to examine rapidly a large number of samples of soil without recourse to elaborate appliances.

It may be pointed out that in certain agricultural industries, particularly in the cultivation of cacao, it is of the greatest importance to ascertain whether the soil does or does not contain an excessive amount of clay, and to determine this fact not only in relation to the surface soil but also as regards the subsoil to different depths. A rapid method of making such an examination, particularly if it is capable of being used by the planter himself, is calculated to be of considerable service.

Briefly stated then, the aims of the work embodied in this paper are: —

(1) To make attempts to devise a suitable method of estimating the shrinkage of soils on drying.

(2) To obtain indications of the possibility of establishing a standard of shrinkage suitable for various crops.

Subsidiary matters that have been dealt with in the course of the investigations are:—

(3) Attempts to co-ordinate the percentage of shrinkage with the proportion of colloidial clay as found by analysis.

(4) The comparison between the percentage of shrinkage in soils and the amount of water needed to bring a definite weight of soil to a standard degree of 'wetness' or plasticity.

The questions of practical importance upon which these results should bring light are the aeration of the soil, problems of drainage and frequency of tillage, and the necessity for applications of lime.

DETAILS OF THE METHODS EMPLOYED.

Following is the method used for these determinations:—

About two or three hundred grams of the soil is placed in a porcelain basin, and kneaded by hand with water until the sample has attained what seems to be a suitable degree of plasticity, great care being exercised in order to obtain a sample of uniform composition. A brick is then made by pressing the kneaded sample into the space between two small cleats nailed on a length of board, the cleats being 1 inch high, 1 inch apart, and 3 inches long. The ends and top of the brick are then trimmed level with the edges of the cleats, and the brick removed. Two fine pins are inserted to their heads into the brick, at as nearly as possible 50 millimetres apart, and the interval between them accurately measured with a pair of dividers or directly by means of a scale. The brick is then laid on its side and left to dry gradually, and the interval between the pins is measured daily until shrinkage ceases.

This method is obviously rough, and is capable of certain refinements. The factors which are likely to affect gravely the accuracy of the method are:

(a) Friction, with consequent distortion, between the lower side of the brick and the surface upon which it rests.

(b) A standard degree of plasticity is not assured.

The question of friction may be dealt with by keeping the side of the brick which rests on the bench covered with thin paper; the paper is placed on the bottom of the mould when making the brick and readily adheres, while if it is of suitable texture, it does not hinder the shrinkage appreciably or cause much distortion. The bricks should be turned over from time to time to prevent them from resting continually on the same side.

In the earlier stages of these experiments, the bricks were roughly standardized by judging when they had been brought to a suitable state of plasticity, the workers being entirely guided by the 'feel' of the material, the ease with which it moulded and the readiness with which it could be reset when fractured in the wet state. As the plasticity of any sample depends upon the percentage of water it contains, and the shrinkage is merely the measure of the water lost on drying, it will be seen that the devising of some means of measuring the plasticity and of establishing a standard degree of plasticity becomes an absolute necessity.

This task was entrusted to Mr. J. L. E. R. Lake, Junior Assistant in the Government Laboratory of the Leeward Islands,

and the trials were conducted along two lines : the addition of measured quantities of water to definite weights of soil, and the determination of the crushing strain of bricks which had been kneaded to an apparently suitable degree of plasticity. The apparatus for measuring the crushing strain is simple, consisting merely of an iron lever on a stand, upon which weights may be hung and under which the bricks may be placed and subjected to pressure; it will be more fully described in a future paper on friability of soils. In explanation of Mr. Lake's work, an abstract of his paper is given, as follows :—

In order to ascertain the effect of different amounts of water on the plasticity of clay, Mr. J. L. E. R. Lake, Junior Assistant in the Government Laboratory, Antigua, carried out experiments under the direction of Dr. Watts, during the time that the latter occupied the post of Superintendent of Agriculture for the Leeward Islands. After a number of preliminary experiments, made with the object of finding satisfactory methods of observation, it was found that comparatively small variations in the amount of water present resulted in relatively large variations in the plasticity of a mass of clay.

As the result of several experiments the following information was obtained :—

Condition of clay as regards moulding.	Weight required to crush in five seconds.	Water on dry brick, per cent.	Water on wet brick, per cent.	Shrinkage, per cent.
Colebrook's soil (Antigua)				
Too soft	...	77·4	43·6	14
Good condition	...	67·9	40·4	15
Too hard	...	57·2	36·6	13
Gunthorpe's soil (Antigua)				
Too soft	...	55·3	34·8	13
Good condition	...	50·5	33·6	13
Too hard	...	45·0	31·0	11
Gunthorpe s (?) (Antigua) ...				
Too soft	500	...	37·4	...
Good condition	1,000	...	32·7	...
Too hard (a)...	1,500	...	31·0	...
„ „ (b)...	1,500	...	31·8	..

As the result of these experiments, the conclusion is reached that for soil that is to be tested for shrinkage to be in good condition for moulding into bricks, it should be of such a degree of plasticity as to be crushed in five seconds by a weight of 1,000 grams at the end of the lever of the testing machine.

As there is no difficulty in getting the soil to be tested into the proper condition for moulding, and as in the case of field or approximate tests, this condition may be fairly gauged by experience without actual reference to the crushing tests for plasticity, it would seem that the shrinkage test is readily applicable for approximate determinations and may prove of service to planters in exploring new districts. For laboratory work it is desirable to ascertain that the blocks used for testing have the proper plasticity, as this is indicated above.

Mr. Lake finally summed up the results of his trials as follows: 'It would appear that for a soil to be in good moulding condition it must just be able to be crushed by a weight of 1,000 grams, at the end of the lever, in less than five seconds.'*

For the present, then, this may be taken as the standard of plasticity.

In dealing with material such as soil, with so many chances of variation in texture, the results can at best be only approximate, and we cannot expect minute accuracy. Many of the determinations, however, were performed in duplicate, and we thus have an opportunity of estimating roughly the degree of accuracy possible. The following results are taken from figures kindly supplied by Mr. Archibald Brooks, and were obtained by him while using this method in connexion with the soils of Dominica:—

* From information contained in papers accompanying the manuscript, it would appear that the actual pressure exerted on the samples were equivalent to 12·6 kilos. [Ed., *W.I.B.*]

SHRINKAGES OF DOMINICA SOILS.

Sample.	Shrinkage, per cent.	Average.	Moisture, per cent. by weight.	Average.
I	5·0		19·5	
	4·2		19·3	
	4·0		18 8	
	5·0	4·5	18·9	19·1
II	2·0		17·7	
	3·0		17·5	
	2·1		18·0	
	2·5	2·4	17·6	17·7
III	4·0		19·2	
	5·0		19 0	
	2·0		19·0	
	3·0	3·5	19·0	19·0
IV	5·0		18·0	
	6·0		18·3	
	5 0		17·8	
	6·1	5·5	18·2	18·1
V	7·0		22·1	
	8·0		21·9	
	8·0		21·1	
	7·5	7·6	21·2	21·6
VI	5·0		23·5	
	5·0		23·0	
	5·1		23·1	
	5·0	5·0	22·0	23·0

From this table we see that the extreme difference of shrinkage in the case of each sample was as follows:—

I. 1·0 per cent.	IV. 1·1 per cent.	Average extreme difference omitting No. III.
II. 1·0 per cent.	V. 1·0 per cent.	
III. 3·0 per cent.	VI. 0·1 per cent.	0·84

There seems little doubt that, if reasonable precautions are exercised in kneading the samples and moulding the bricks, a considerable degree of accuracy may be obtained. Mr. Brooks's results furthermore, were gained before the method for standardizing plasticity had been evolved, and doubtless an even greater degree may be obtained by utilization of the lever test. In any case, as it is not easy to measure the

positions of the pins to within ½-mm., it is clear that the shrinkages recorded are liable to an error of fully 1 per cent.

The fact that the percentages of water on the several samples as detailed in the above table, are not directly proportional to the shrinkages, per cent., would indicate that the adoption of a standard plasticity is necessary for greater accuracy. A rough proportionality is evident, but the whole question of the relation between moisture content and shrinkage needs further work. If they both depend on the percentage of clay present, as is assumed, the proportionality should be very exact.

In Grenada, a few determinations have been made which again bear out the accuracy which is possible when the method is used with care. An attempt was also made at estimating the colloidal clay by flocculating with various reagents, but the method has not yet been carefully worked out. Results are given in the following table:—

SHRINKAGES OF GRENADA SOILS.

Sample.	Shrinkage, per cent.	Average.	Colloidal clay, per cent.	Average.	Ratio: gravels & sands to silts.
A ...	16 15	15.5	7·7 11·8	9·7	1:1·1
B ...	15 11	1·30	8·5 11·3	9·9	1:0·9
C ...	8 8	8·0	2·5	2·5	1:0·8
D ...	16 16	16·0	6·5 9·1	7·8	1:1·1
E ..	7 5	6·0	2·0	2·0	1:0·2

A rough proportionality between percentage of colloidal clay and that of shrinkage is here evident. In order to gain a further insight into the value of the shrinkage determination as an index of the working properties of the soil, the last column of the table has been added; the figures of the column were obtained by physical analysis carried out in accordance with the usual methods, and they may really be regarded as being in lieu of a planter's report on the qualities of the soils.

The results in St. Lucia, where the work was performed by Mr. Thomas Worm, are given in the following table. They again bear witness to the degree of accuracy possible in this method—even without mechanical standardization of plasticity:—

SHRINKAGE OF VARIOUS SAMPLES OF SOILS EXAMINED IN ST. LUCIA.

Estate or situation.	Shrinkage, per cent.	Kind or condition of crop. Nature of land.
Section 5, Union	14	Cacao. Red-brown; flat.
Section 5, "	15	" " " "
Section 5, "	16	Cacao. Black; stiff; flat.
Section 3, "	13	Cacao. Yellowish brown; flat.
Section 3, "	12	Cacao making best growth. Chocolate-brown; flat.
Section 3, "	14	Cacao. Brown; flat.
Section 3, "	15	Cacao not growing well. Chocolate-brown; flat.
Section 12, "	14	Cacao not growing well. Chocolate-brown; flat.
Section 12, "	14	Cacao not growing well. Chocolate-brown; flat.
Section 12, "	15	Cacao not growing well. Chocolate-brown; flat.
A. Mallet's estate	6	High wood. Fawn-coloured; sloping.
Houlemont	8	High wood. Stone-coloured; sloping.
Roblot, Forest Land	6	High wood. Light-brown coloured; sloping.
Belair estate	8	Cacao making good growth. Chocolate-brown; flat.
Belair estate, experi-plot	8	Cacao making good growth. Chocolate-brown; flat.
Near river, Belair estate	8	Cacao making good growth. Chocolate-brown; flat.
Belair estate, Lower Guinea	11	Cacao making fair growth. Light-brown; sloping.
Grenville estate, Crown lands	8	High wood. Dark-brown; sloping.
Lartigue estate	10	High wood. Blackish-brown; sloping.
La Baye	8	Cacao growing well. Lightish brown.

Application of the Method in Agriculture.

Up to the present there have been only few attempts to find the relation between the percentage of shrinkage of a soil and its crop-bearing power. In this case the trials were made in connexion with cacao on an estate in Dominica, and the results are remarkable enough to warrant some attention. The lines of trial were roughly as follows. Shrinkage determinations were carried out on the surface and subsoils of several cacao fields, and then a report was obtained from the manger on the condition of the cacao from the fields supplying the samples of soils and subsoils. The manager's report was, of course, prepared independently of the observations in the laboratory. The results are given in the following table:—

Sample.	Shrinkage, per cent.	Condition of cacao.
A. Surface soil ...	8	Cacao growing well
Subsoil	12	
B. Surface soil ..	13	Cacao failing
Subsoil	17	
C. Surface soil ...	12	Cacao very poor
Subsoil	11	
D. Surface soil ...	9	Cacao doing well
Subsoil	12	
E. Surface soil ...	10	Cacao growing well
Subsoil	15	
F. Surface soil ...	13	Cacao fair
Subsoil	17	
G. Surface soil ...	13	Cacao died
Subsoil	11	
H. Surface soil ...	14	Cacao died
Subsoil	17	

Making his conclusions from these results, Dr. Watts has attempted to put forward provisional standards of shrinkage for surface soils and subsoils. These standards, being based on comparatively few determinations, are of course liable to modification; for the present they may be accepted as applying only to soils similar to those investigated, and would naturally be likely to need modification when applied to crops other than cacao.

The limits of shrinkage proposed are as follows :—

Shrinkage, surface soil,	greater	than 10	per cent.	Bad
" " "	less	" 10	"	Good
" subsoil	greater	" 12	"	Bad
" "	less	" 12	"	Good

Applying these to the fields in question, and comparing the results with the manager's report, we obtain the following :—

Sample.	Quality of suface soil and sub-soil.	Quality of soil.	Manager's report.
A. Surface soil ...	Good	Fairly good to good	Cacao growing well
Subsoil... ...	Good		
B. Surface soil ...	Bad	Bad	Cacao failing
Subsoil... ...	Bad		
C. Surface soil ...	Poor	Fair to poor	Cacao very poor
Subsoil... ...	Good		
D. Surface soil ...	Good	Very good	Cacao growing well
Subsoil... ...	Good		
E. Surface soil ...	Good	Fairly good to good	Cacao growing well
Subsoil... ...	Poor		
F. Surface soil ...	Bad	Bad	Cacao fair
Subsoil... ...	Bad		
G. Surface soil ...	Poor	Poor	Cacao died
Subsoil... ...	Good		
H. Surface Soil ..	Bad	Bad	Cacao died
Subsoil... ...	Bad		

Sample F is the only case in which the standards do not seem to apply.

A further series of trials was made in a different valley of a neighbouring plantation, and although the observer had had no previous experience of the work, convincing results were again obtained of the value of these standards as a clue to the suitability of the soil for cacao. In this case the cacao was young. The particulars are as follows :—

Sample.	Shrinkage, per cent.	Condition of cacao.
I. Surface soil	8	...
Subsoil	4	
II. Surface soil	8	Good
Subsoil	8	
III. Surface soil	12	Poor
Subsoil	10	
IV. Surface soil	10	Good
Subsoil	10	
V. Surface soil	10	Good
Subsoil	10	
VI. Surface soil	10	Fair
Subsoil	13	

CONCLUSIONS.

The value of these trials lies in the fact that they place stress upon the importance of taking into account the purely physical properties of soils. In the great majority of cases, the physical properties of a soil are the most important in their effect upon crops, and it is but rarely that we find large areas unsuited for a crop because of chemical peculiarities. The problems of draining, aeration, tillage and root development are all closely connected with the purely physical attributes of the soils we handle, and have as a rule little relation to soil chemistry. In practice, too, an additional value is possessed by the trials, as they have led to the formulation of a method that can be employed for assisting the planter to avoid unsuitable soils.

The usual methods of physical analysis, whereby the soil is separated into grades of particles of varying sizes, are laborious, although they have the advantage of exhibiting the qualities of soils in a graphic and easily understood fashion. The determination of shrinkage should hardly replace these methods, but is of particular importance in linking the 'working' properties of soils—the properties of importance to the planter—with peculiar manifestations which are associated in the laboratory with the name Colloids. Shrinkage determinations may be regarded as a measurement in the laboratory of the trouble that colloidal clay causes the planter in the fields.

The investigations so far carried on have fairly proved one point, namely that the estimation of shrinkage is capable of

a considerable degree of accuracy. Future efforts should be along the lines of erecting standards of shrinkage for various crops, and of investigating further the accuracy of the standard temporarily adopted for cacao. The subsoil should be looked on as of perhaps greater importance than the top soil when dealing with deep rooting and permanent crops. Much good work remains to be carried out in determining the limits of shrinkage to be assigned to soils for various crops, and citrus fruits, cotton, rubber, sugar-cane and spices should eventually be brought under the similar standards, and have their respective suitable areas assigned to them.

THE FRIABILITY OF SOILS.

(Compiled from the notes of investigators, by Gilbert Auchinleck, B.Sc., F.C.S.)

In the first part of this paper, certain methods for the determination of shrinkage of soils which had been elaborated in the Leeward Islands were described, and an attempt made to point out the possibility of using results in a practical manner. Simultaneously with the work on shrinkage, trials were inaugurated by Dr. Watts with the intention of devising some suitable method of measuring the degree of hardness which soils might attain if left uncultivated for too long a period. This factor, which is referred to as Friability, should be of importance to the planter, enabling him to gain a more accurate notion of the physical nature of his soil, and perhaps even to estimate the suitability of his soil for various crops.

The experiments in this series were carried out entirely in the Government Laboratory for the Leeward Islands, and are not on quite as extensive a scale as the shrinkage trials. The actual experimental work was performed by the writer, and by Mr. J. L. E. R. Lake.

Aim of the Investigations.

At an early stage, the work branches into two main lines, as follows :—

(a) The estimation of the effect on the tilth of soil, of mere wetting, apart from kneading or trampling.

(b) Determination of the maximum degree of hardness which a soil might attain if left untilled and at the same time subjected to trampling.

As in the case of shrinkage, the percentage of clay in the soil is the determining factor in these results. The larger the amount of clay present, the greater the ease with which a soil will lose tilth, the property of setting hard in very clayey soils being operative even when no actual trampling has occurred. Mere wetting and drying will produce cohesion and consequent 'setting' of clay.

Suggestions are also made in this paper for establishing standards of friability. Soils are classified as tillable, moderately tillable and so on, and an attempt has been made to co-ordinate the question of general health of one crop—cacao—

with the results obtained by this method. This work is by no means complete and is well worth continuing. Determinations of purely physical characters of soils, such as shrinkage and friability are so easily carried out, and are of such importance to the planter that they should gradually be adopted and should become one of the most important clues to the question of suitability of soils to various crops. Except in the case of chemically abnormal soils, which are rare, the physical properties of soils may be regarded as of greater importance than the chemical; the questions of draining, frequency of forking, and use of lime are all bound up with the physical characters.

Details of Method Used.

In the method, as evolved, the determinations were carried out by moulding cylinders of soil, of definite diameter and length, and subjecting them to end-pressure until they broke, the weight nacessary being recorded. The fittings and apparatus required are:—

(a) Cylinders to serve as cores for making the moulds.
(b) Moulds.
(c) A lever for the crushing.

The cylinders are most properly made of some hard wood which will not warp or shrink; and should have a good smooth surface so that the paper moulds can be readily slipped off. Three diameters were tried in these experiments, namely, 1 inch, $1\frac{1}{4}$ inch, and $1\frac{1}{2}$ inch; $1\frac{1}{4}$ inches is recommended as the most convenient.

The moulds are made as follows. A double thickness of stout brown paper is wound around the cylindrical core and the free edge secured with gum: the tube thus obtained is then cut into lengths of $2\frac{1}{4}$ inches, and these lengths used for casting the soil cylinders.

The lever for crushing the casts is often subjected to great strain and is best made entirely of iron, its parts being: a bed-plate 21 inches × 6 inches, perforated at both ends to allow its being screwed down to a table; at one end are two uprights 4 inches high, set closely and holding a pin or fulcrum on which swings the lever bar; this latter is fitted at its free end with a hook, and is exactly 2 feet long from the fulcrum to the point of suspension of the hook. The under side of the lever bar is divided by deep file-marks into halves, quarters, eighths, etc., the file-marks serving the double purpose of measurement and of holding a short stout cylinder of iron by which pressure is transferred to the soil-casts. In order to transfer the pressure evenly, the top of the block to be tested is capped by a halfpenny on which rests the stout cylinder lying in the file-mark of the lever bar.

The actual pressure of the lever on the cylinder of soil is given by weight of lever at place of contact + distance of fulcrum to sample ÷ distance of fulcrum to block + weight hung.

The casts, which are devised to represent the effect of wetting on a soil in good tilth are made by inserting the soil in a dry condition in small quantities, and wetting after each addition; in this way the cast is gradually built up without any possibility of

kneading. The other casts are made by filling the moulds with thoroughly kneaded wet soil, the sample being well pressed with the forefinger after each addition. Both kinds of cast are allowed to dry in the moulds at the temperature of the air, the drying usually requiring three to six days.

The main points requiring attention in making these casts are :—

(1) All possibility of kneading in the case of 'unkneaded' samples should be avoided.

(2) Drying in all cases should be gradual, to avoid cracking.

(2) The casts should be dried in the moulds, to prevent warping.

As there is a considerable amount of shrinkage in the casts on drying, it will be found safest always to gauge their diameter in two or three places when they are dry.

Results of the Trials.

A short preliminary series of tests was made on soils from Antigua and Dominica, with the following results :—

No.	Locality.	Treatment.	Size of cast, inches.	Crushing weight, kilos.
I.	Antigua.	Unkneaded : inserted wet.	2 × 1	3·6
		Kneaded	2 × 1	8·6
		do. dup.	2 × 1	7·7
II.	Antigua.	Unkneaded : inserted wet.	2 × 1	31·7
		do. mould filled dry and wetted ; dried out of mould.	2 × 1	41·3
		Kneaded.	1¾ × 1	
		do. dup.		
III.	Antigua.	Unkneaded : inserted wet.	1¾ × 1	24·7
		Kneaded : dried in mould.	1¾ × 1	178·3
		do. do.	1¾ ×	197·2
IV.	Antigua.	Unkneaded : inserted and wetted in small amts.; dried out of mould.	2 × 1¼	1·3
		Kneaded ; dried out of mould....	2 × 1	109·2
V.	Dominica.	Unkneaded	...	Broke on handling.
		Kneaded...	...	Crushed under weight of lever.
VI.	Antigua.	Unkneaded ; dried out of mould....	2 × 1	24·4
		Kneaded : dried out of (faulty) mould. ..	2 × 1	84·3
		Kneaded ; moulded to size by hand ; dried out of mould (faulty).	2 × 1	86·5

In this table we note that the range of friability in the kneaded samples is from 197 kilos. in sample III to a negligible weight in sample V. It is of interest to state that sample V is from virgin forest in Dominica, where the percentage of humus was abnormal (over 30), while No. III represents one of the heaviest clay soils in Antigua. Sample I is from a garden in Antigua, which presumably contained a large amount of leaf mould.

Trials on a somewhat larger scale were next made, the results being given in the following table. These figures, which in most cases are in duplicate, show that a fair degree of accuracy may be expected; thus all the unkneaded samples of II, III and IV, which are from Dominica soils containing a large percentage of humus, broke on freeing from the moulds, thus manifesting their small degree of cohesion.

Locality.	Diameter of cast. wet, inches.	Diameter of cast. dry, inches.	Crushing, unkneaded.	Weight in kilos., kneaded.
I. Antigua ...	1½	1¼	11·0 13·4	
II. Dominica ...	,,	,,	Broke on freeing ,,	124·4 42·8
III. Dominica ...	,,	,,	Broke on freeing ,,	35·0 78·7
IV. Dominica ...	,,	,,	Broke on freeing	67·1
V. Antigua ...	,,	,,	47·4 lost	126·9 119·6

A fairly complete series of determinations was next made, using Dominica soils and working on both surface soils and subsoils. The figures are of considerable interest, and are given in the following table. In this, the capital letters refer to surface soils and the small letters to the corresponding subsoils :—

Soil.	Crushing strain in kilos.	
	Unkneaded.	Kneaded.
A	Broke on handling	37·2
a	do.	78·0
B	5·9	104·0
b	5·8	83·8
C	Broke on handling	55·6
c	do.	68·5
D	do.	60·3
d	do.	60·3
E	do.	58·0
e	5·0	38·4
F	1·2	78·3
f	2·3	74·4
G	5·4	61·1
g	4·8	51·6
H	Broke on handling	128·3
h	do.	48·3

Degree of Accuracy, and Possibility of Adopting Standards, of Friability.

As far as these trials have extended, they have shown that the method is not of great delicacy. Thus in Table II, the variations in the duplicate determinations of the samples are as follows :—

I. Unkneaded	2·4	kilos.	in	13·4
II. Kneaded	7·8	„	„	42·8
III. „	7·3	„	„	126·9

an error of 18·0 per cent. 18·2 per cent. and 5·7 per cent., respectively. While this is recognized, it is apparent that the method is quite accurate enough to classify soils on broad lines ; it would be impossible to confuse two such soils as those giving V and II, with one another. The difference between soils of the type obtaining in Dominica, namely forest soils with large

admixtures of humus, and those of Antigua—clays—is readily detected by this method. When we remember that the results given in this paper represent the first trials of the method, there seems good reason to hope that with greater care in the future it will be possible to obtain more accuracy. Efficient sampling and scrupulous care in kneading are the two ways along which we may hope for improvement.

A general classification of soils according to their friability is the end to which these trials naturally move, and the following proposals have been put forward by Dr. Watts. The standards are based on thirty-three samples, and hence are probably open to a certain amount of modification, as further data become available :—

Unkneaded cylinders.	
Open	Crumbles on handling cast.
Very friable	Up to 1·5 kilos.
Friable	1·6 to 4·0 kilos.
Hardly friable	4·1 to 10·0 kilos.
Heavy	Over 10·0 kilos.
Kneaded cylinders.	
Very tillable	Up to 5·0 kilos.
Tillable	5·1 to 10·0 kilos.
Moderately tillable	10·1 to 50·0 kilos.
Hardly tillable	50·0 to 100·0 kilos.
Not tillable	100·0 to 200·0 kilos.

Concluding Remarks.

The point of importance to remember in studying the results set forth in this paper is that they must be regarded as merely the introduction to further work. So far, the sole means by which we can gain an idea of the physical properties of soils has been some method of separation by elutriation—a method which gives a good idea of the proportions in which grains of various sizes exist in a soil, but yields only indirect evidence on such important physical properties as cohesion and shrinkage. A large amount of good work can now be done in improving the methods herein described, and in erecting standards of shrinkage and friability for soils and for special crops.

A NOTE ON SOIL SKRINKAGE AND THE RESULTS OBTAINED BY THE DETERMINATION OF ITS MAGNITUDE.

(The following note in connexion with soil shrinkage has been supplied by Mr. H. A. Tempany, B.Sc., Superintendent of Agriculture for the Leeward Islands.)

The most suggestive point in this work seems to me to lie in the first place in the results obtained by gradual addition of water to soils, when a point is reached with some sharpness at which the soil reaches its maximum plasticity. In the case of two soils this was found in the one case to occur when approximately 51 c.c. of water had been added to 100 grammes of dry soil, and in the other when 67·9 c.c. had been added to 100 grammes of dry soil.

The plastic properties of soils are generally admitted to be conditional on the presence of so-called colloided clay, really consisting of matter in an extremely fine state of subdivision. It is a property of such substances that they are capable of entering, with water and other fluids, into a species of physical combination termed hydrogels or jellies ; an example of this is colloided silica. The following description of these hydrogels is abridged from Zgismondy's Colloids and the Ultramicroscope. In hydrogels, the individual particles are separated by an aqueous envelope; but they nevertheless attract one another. Upon further dehydration, the hydrogel gradually solidifies; because of the decreasing distance between the particles upon desiccation, the action of the forces of cohesion speedily increases. According to Butschli and Van Bemmelen, gel formation is to be considered a segregation process whereby there occurs a separation into two fluids, one of which subsequently solidifies. The fluid properties of such a gel are explained as being due to the slight friction of aqueous envelopes against each other, and the surface tension to the attraction which the extremely small particles exercise on one another. Butschli has shown that hydrogels have almost invariably a fine webbed microstructure usually termed the gel skeleton.

In view of the above, the following appears to present a satisfactory explanation of what occurs in the case of the addition of water to soils; when the point of maximum plasticity is reached, the clay particles are all completely surrounded by water, and a clay hydrogel is formed which constitutes a gel skeleton ramifying throughout the soil. As the soil dries, the skeleton contracts and in its meshes draws together the larger particles which are incapable of gel formation. Finally a point is reached when packing of the larger particles can proceed no further: this of course depends on the number of larger particles present; contraction ceases and the gel skeleton becomes broken up into small pieces throughout the block.

An approximate proportionality may be expected to exist between the agricultural clay present in a sample, as determined by physical analysis, and the contraction observed. The proportionality will be only approximate, since all the particles present in agricultural clay are not of the colloid order of magnitude.

To investigate this point, I have collated a number of results in the shrinkage determination quoted in these papers with the percentage of agricultural clay in the samples as determined by analyses. I have also performed a series of further shrinkage determinations on existing samples of soil in the laboratory and collated them with the agricultural clay determinations made on the same sample.

No.	Soil.	Agricultural clay, per cent.	Shrinkage per cent.	Per cent. agricultural clay / Per cent. shrinkage.
1	Picard, Dominica, a. ...	64·4	12·2	5·28
2	,, ,, b. ...	73·1	16·7	4·38
3	,, ,, c. ..	69·5	11·4	6·10
4	,, ,, g. ..	50·4	11·4	4·41
5	,, ,, h. ...	72·8	16·7	4·36
6	Gunthorpes, Antigua ...	65·0	13·0	5·00
7	Colebrooks, Antigua ...	88·0	15·0	5·85
8	Iles Bay, Montserrat ...	38·6	9·0	4·30
9	Olveston, Montserrat ...	57·3	12·0	4·77
10	Riversdale, Dominica ...	23·8	4·0	5·90
11	Round Hill, Nevis ..	31·1	8·0	3·80
12	Spring Hill, Nevis ..	31·5	8·0	3·95
13	Indian Castle, Nevis ...	32·7	7·0	4·65
	Mean			4·82

When the relatively large possibilities of error on the shrinkage determinations are taken into account, the value obtained for the ratio $\frac{\text{Percentage agricultural clay}}{\text{Percentage shrinkage}}$ exhibits a very fair degree of constancy; with larger refinement in measuring, it may be expected that the constancy would be greater. The employment of the mean factor given above may afford a ready means of determining the approximate percentage of agricultural clay in a sample of soil, without having recourse to elaborate and tedious methods of physical soil analysis; if so, it should serve as a valuable aid to the soil analyst, inasmuch as it would enable a considerable amount of useful information to be obtained with a small expenditure of labour. Once a physical type for a soil has been established, it should be possible to study by means of it, in considerable detail, local variations from the type.

THE ESTIMATION OF CARBONATES AND OF ORGANIC CARBON IN SOILS.

BY DR. FRANCIS WATTS, C.M.G., ETC.,

Imperial Commissioner of Agriculture for the West Indies.

The fact that the methods described below for the estimation of carbonates and of organic carbon in soils have been found useful in several quarters has led to their publication in this volume of the *West Indian Bulletin*, in order that they may be available more widely. They first received description in a Report on the Physical and Chemical Analyses of the Soils of Dominica, 1902, made by the writer and issued by the Imperial Department of Agriculture.

ESTIMATION OF CARBONATES.

Considerable interest and importance attach to the exact determination of the carbonates in the case of soils containing such small amounts as those commonly found amongst the volcanic soils of the West Indies. A special process has been devised, which is both simple and accurate, and allows relatively large quantities of soils to be taken for the determination when necessary.

A quantity of soil capable of evolving 50 to 100 c.c. or so of carbon dioxide (in cases of feebly calcareous soils 25 grammes proves a convenient quantity) is placed in a strong round-bottomed flask capable of holding 300 c.c.; to this 100 c.c. of water is added. The flask is fitted with a rubber stopper, through which passes a funnel with a stop-cock, and also a tube leading to a simple form of Sprengel mercury pump, such as can be readily constructed in any laboratory. It is desirable to have a bulb or two blown on the vertical part of the tube leading from the flask to the pump (in the pump in use, a calcium chloride tube forms the vertical connexion) in order to arrest any liquid which may foam over.

All being connected, the pump is started and allowed to form a partial vacuum and then stopped. A strong gas receiver filled with mercury is now placed over the delivery end of the pump; 10 c.c. of strong hydrochloric acid are cautiously allowed to run from the funnel into the flask and the flask is shaken: if much carbonate is present there is vigorous effervescence and gas (air and CO_2) begins to collect in the receiver; when the effervescence has subsided, the flask is gently heated until the vacuum is destroyed and the contents begin to boil. The pump is now started cautiously, the mercury being allowed to flow at such a rate as to maintain steady boiling in the flask without the further application of heat. This flow is continued until the flask has become cool, when the whole of the carbon dioxide will have been expelled. A special form of receiver is used, but a strong tapped separatory funnel with a short delivery tube has been successfully employed, a rubber stopper being preferably substituted for the usual glass one. The description of the method of manipulation which] follows applies to the use of a separatory funnel as a receiver.

When the gas is collected, the receiver is removed from the pump, the rubber stopper inserted and a drop of methyl orange solution is allowed to flow through the delivery tube and stop-cock, now held vertically upwards, into the receiver; should any hydrochloric acid have *splashed* over (none will distil over), the methyl orange will be reddened. In this case dilute solution of barium hydrate must be allowed to flow in, drop by drop, until the liquid over the mercury is exactly neutral to the indicator. It very rarely happens that any hydrochloric acid is found, but it is as well to exercise the precaution of testing for it.

No hydrochloric acid being found, or if found, being removed, 25 c.c. of strong solution of barium hydrate (of known strength), accurately measured, are allowed to run into the receiver. This is readily effected by slipping a short piece of rubber tubing over the delivery tube of the separatory funnel receiver, still kept vertically upwards, the point of a 25-c.c. pipette containing the barium hydrate solution is inserted into the rubber tubing and the solution drawn gently into the receiver: a drop or two of phenol-phthalein solution is now added, washed in with water and the receiver shaken to bring the gas into contact with the fluid: should more baryta be required, another 25 c.c. are added as before. In a few minutes, with steady shaking, the whole of the carbon dioxide is absorbed: the receiver is now inverted and the contents titrated by means of $\frac{N}{5}$ hydrochloric acid, this being effected by inverting the receiver into the usual position and running in the $\frac{N}{5}$ acid through the neck. From the amount of barium hydrate neutralized, the amount of carbon dioxide and its equivalent in carbonate of lime are readily found.

This process is easily worked, is rapid and accurate.

ESTIMATION OF ORGANIC CARBON.

There are certain difficulties connected with the estimation of this substance in soils. The process of Cross and Bevan, *Journal of the Chemical Society* (*Transactions*) Vol. LIII, 1888, p. 890, has been adopted as specially meeting the requirements of soil analysis. The operation consists in treating the substance under investigation with concentrated sulphuric acid followed by chromic anhydride, when a mixture of carbon dioxide with some carbon monoxide is evolved. This is measured and the amount of carbon in the gas ascertained by calculation. As pointed out by Cross and Bevan, there is an advantage in performing a gasometric analysis, in that similar volumes of carbon monoxide and dioxide contain equal weights of carbon.

The analysis is performed as follows: About 2 grammes of *very finely powdered* soil, or as much as may be expected to yield about 90 to 100 c.c. of gas are placed in a small flask of about 50 c.c. capacity having a side tube in the neck (Wurtz flask). To this, 10 c.c. of concentrated sulphuric acid are added and mixed by gently shaking. The flask is now attached, by means of the side tube and a piece of stout rubber tubing, to

a suitable apparatus for measuring gas described below. When first attached the flask is brought into such a position that the neck is horizontal, a plantinum boat containing chromic anhydride is placed in the neck, and the neck closed by means of a rubber stopper, care being taken that the neck is not soiled during the introduction of the chromic anhydride so as to ensure that none comes in contact with the rubber stopper. While in this position, the apparatus is allowed to assume the temperature of the air; when this is accomplished, the gas-measuring apparatus is adjusted.

The gas-measuring apparatus consists of a nitrometer with a three-way cock connected with a reservoir of mercury and a manometer tube. To adjust the apparatus, the nitrometer is filled with mercury by raising the mercury reservoir while the nitrometer is in communication with the outside air through the appropriate channel of the stop-cock. The flask is now also brought into communication with the outside air by means of the stop-cock: thus the contents of the entire apparatus are at atmospheric pressure. The flask is now brought into communication with the measuring apparatus, by a proper turn of the stop-cock. The flask is then brought into a vertical position whereby the chromic anhydride falls into the flask: this is brought into intimate contact with the soil and acid in the flask by gently shaking, where upon gas is at once given off. The flask is now immersed in a bath of boiling water to complete the reaction, and is agitated occasionally; in about twenty minutes the evolution of gas ceases, the hot water bath is removed, the apparatus allowed to resume the temperature of the air, the mercury levels in the measuring apparatus accurately adjusted and the volume of gas evolved measured. This volume is simply that found in the measuring apparatus, and is independent of that contained in the flask and its connexions, which remains constant.

As there is always a slight evolution of CO_2 on the addition of the sulphuric acid, this to a certain extent saturates the liquid with gas; it has not been customary, therefore, to make any correction for the solubility of the gas in the acid used, as suggested by Cross and Bevan.

From the volume of the gas evolved after correction for temperature and pressure, the weight of carbon is easily calculated.

This process is preferable to that in which the soil is digested with bichromate of potassium and sulphuric acid, and the evolved carbon dioxide absorbed by caustic soda and weighed. It has been shown by Cross and Bevan that under these conditions the carbon is under-estimated owing to the formation of carbon monoxide, which escapes absorption. It is also much more convenient than determining the carbon by combustion in oxygen, for in this case the discrimination between the organic carbon and the carbon of the earthy carbonates is troublesome.

No attempt is made to estimate the humus as such, the organic carbon multiplied by the factor 1·724 being regarded as humus, or perhaps more properly as potential humus. In the

tropics, where the decomposition of organic matter is rapid and continuous, there appears to be good reason for adopting this course, for vegetable matter newly added to the soil in the form of green dressings or of pen manure usually takes little time to exert a beneficial action. The estimation of the total organic carbon therefore appears to be preferable to estimating the humus only.

THE EPIZOOTIOLOGY OF ANTHRAX.

BY STEWART STOCKMAN, M.R.C.V.S.,

Chief Veterinary Inspector of the Board of Agriculture, England.

[A paper on this subject was read by Mr. Stockman at a meeting of the Midland Counties Veterinary Medical Association, held at Wolverhampton on May 9, 1911, and was printed in the *Veterinary Record* for August 19, 1911. The former part of the paper is reproduced from the journal mentioned in the article; while extracts have been taken from the latter portion, attention being given to such matters as are of greatest interest in the West Indies.—Ed., *W.I.B.*]

DIAGNOSIS.

In the cases of cattle and sheep the usual history is that one animal has been found dead or in a moribund condition, and that signs of serious illness had not been observed until shortly before death. Anthrax may or may not be suspected by the owner. Anthrax, however, is not always fatal, and inasmuch as several animals may have contracted the disease from the same source, and be less severely attacked, or in different stages of the disease, it is advisable to make use of such clinical aids to diagnosis as can be applied on the spot to animals in contact. This applies especially to cows in byres, and it has frequently been observed that some of the contacts to an animal which has died of anthrax show a suspiciously high temperature.

In the cases of horses and pigs there are often certain objective symptoms to guide one, such as swelling of the tissues around the throat, and in the former severe colic. These external lesions are of great value in connexion with diagnosis during life and after death, but, while their presence is strongly indicative of anthrax, their absence cannot be regarded as satisfactory evidence that the disease does not exist.

The irrefutable evidence of the existence of anthrax is the presence of the anthrax bacillus in the body fluids or tissues. The blood is the fluid from which preparations can be most

conveniently made for microscopical examination, and, since the bacilli seldom invade the blood stream in sufficient numbers to be detectable until the animal is practically moribund, a positive diagnosis follows usually upon the finding of anthrax bacilli in the blood after death. It is seldom indeed that the bacilli have not invaded the circulation in large numbers in cattle and sheep just before death, but very occasionally cases of anthrax are met with in these animals in which a microscopical examination of blood from the peripheral vessels fails to reveal the presence of anthrax bacilli, and other methods of diagnosis have to be employed. In pigs and horses it frequently happens that the animals die of anthrax before the bacilli have invaded the circulation in large numbers, and under such circumstances diagnosis by the microscopical examination alone of smears from the blood in the peripheral vessels often fails. It is advisable in horses and pigs to make smears from a gland near the surface, and from any oedematous fluid which may be present, as well as from the blood.

Given that these methods of examination have been applied with a negative result, there is nothing left except to seek for the cause of death by an examination of the internal organs, still paying due regard to the possibility of anthrax existing, and taking all reasonable precautions against infective material being disseminated. A great deal of importance is often attached to finding a carcass of an animal tympanitic, with blood oozing from the orifices. Without wishing to minimize the importance of this in arousing suspicion of anthrax, I would like to remark that no conclusion can be drawn from its presence or absence. It may happen that this further examination will tend to increase one's initial suspicions. For example, if enlargement of the spleen be found, with a fluid tar-like appearance of the pulp, or if the intestines and lymph glands are markedly congested, anthrax should always be suspected, and smears for further microscopical examination should be made from the altered organs.

A fairly common lesion in pigs, and one of great diagnostic value, is the presence of necrotic areas on the mucous membrane of the pharynx. These vary in size, but are commonly as large as a shilling. The centre is dark, almost black in colour, slightly raised, and the edges are level with the mucous membrane. There is seldom any difficulty in finding anthrax bacilli in preparations made from these areas.

In cattle and sheep anthrax may be confused with black-leg. The local lesions of the latter disease are generally sufficient for differential diagnosis, but it must not be forgotten that in sheep dead of black-leg, lesions of the skeletal muscles may be very slight, or even absent. It is sometimes stated that the bacillus of black-leg does not invade the blood stream. This, however, is an error, and the finding in almost pure culture of an appreciable number of bacilli like those of black-leg in preparations made from the blood is almost sufficient evidence to exclude anthrax. In the horse one may be misled during the life of the animal by the belief that it is suffering from serious intestinal trouble. In dealing with

the carcass of an animal, however, it is unnecessary to attach a great deal of importance to differentiating finely between the macroscopic lesions of anthrax and other diseases, because if the circumstances or lesions are such as to make one suspect anthrax, the question can be decided by establishing the presence or absence of a definitely ascertained microbe; these things are happily no longer the matters of opinion which men of the more ancient clinical school found time to wrangle about.

We have next to consider the methods of establishing the presence of anthrax bacilli in fluids and tissues, and microscopical examination naturally comes first for consideration. I take it, it may be assumed that everybody knows what is meant by a smear, that smears should be made from blood present in the peripheral vessels, such as those at the base of the ear, that they should not be made from blood found oozing from the orifices, that in the case of the horse and pig it is highly advisable also to make smears from a superficially placed lymphatic gland, and that for bacteriological examination an oil immersion lens is indispensable. The smears are fixed by heating the glass slides over a flame, after the fluid has been dried. Amongst the specimens sent to the laboratory purporting to contain anthrax baccilli a few have been unstained cover-glass smears of blood mounted in balsam, and I have known members of our profession who claimed that they had no difficulty in identifying anthrax bacilli in unstained preparations. This, however, is rapidly becoming a lost art, and one of the penalties we have had to pay for the advance of civilization is that we must now stain our anthrax preparations. The anthrax bacillus is not difficult to colour with any of the bacterial stains, nor is it difficult to identify, whatever be the stain employed, provided the material for the smear has been obtained very soon after the death of the animal and the organisms are fairly numerous. The classical description of the anthrax bacillus in preparations from the blood is: a rod-shaped organism measuring 5 to 8 *Microns*. by about 1 to 2 *Microns*, ends square cut, or showing cup-shaped depressions, consisting of a central rod of protoplasm bounded by a translucent capsule, occurring singly, or in twos or threes joined end to end, but not as long filaments. To see anything very closely resembling the above picture, one must examine perfectly fresh material taken soon after the animal's death. If one expects always to find it in preparations made under the conditions obtaining in the field of practice, the expectation will not be realized. The veterinary inspector frequently does not arrive on the scene until twenty-four or thirty-six hours, or even more, after the animal has died, and it is common knowledge that in this time even the blood in the peripheral vessels may become grossly contaminated by the organisms of putrefaction, especially during hot weather. These organisms, as it were, crowd out the anthrax bacilli, and as some of them, particularly the bacilli of malignant œdema, bear a certain resemblance to anthrax bacilli, the problem of identification becomes more complicated. Further, it is also well known that anthrax bacilli contained in blood, especially under the anærobic conditions obtaining in the blood vessels of an unopened carcass, undergo degenerative changes, and

disappear in a variable time. These changes give rise to distorted forms, which, up to a certain point, may aid identification, and beyond that make it more difficult. The central protoplasm may be twisted, shrivelled and very granular, but the most marked changes are probably observed in connexion with the capsules, which may swell up to several times their original size, and assume curious shapes; they may also rupture. Sometimes the protoplasm inside the swollen envelope takes the stain very feebly, giving rise to what may be referred to as ghost forms. In preparations made from tissue which has been exposed to the air for some little time one may also see anthrax threads of considerable length, made up of bacilli of about equal length joined end to end, and there may even be sporulating forms in warm weather. In the majority of cases, however, the long forms seen in preparations are not anthrax filaments; they are threads of the malignant oedema bacillus, made up of rods of very unequal length, and of greater thickness than those of anthrax when stained in certain ways. Other filaments of bacilli more or less resembling anthrax may also be present when the material has become grossly contaminated.

I have purposely said nothing about motility as an aid to differentiating between anthrax and other micro-organisms, as I consider the manipulations necessary to put it in evidence are too dangerous to be made use of by practitioners. The anthrax bacillus is not motile.

Two methods of staining are particularly helpful in the identification of anthrax bacilli, while certain others should be avoided. First, we may take Gram's method. This is not a good method for staining the anthrax bacillus, as it usually shrivels the protoplasm, renders it very granular, and causes a certain amount of distortion, which may make identification somewhat difficult in certain preparations. On the other hand, it may be usefully employed, when necessary, to distinguish between the anthrax bacillus, which is Gram-fast, and other somewhat similar microbes which are not—malignant oedema, for example. The most misleading stain of all is gentian violet, which is apt to colour the envelope of the anthrax bacillus, giving the rod an unnaturally thick appearance. This increases the difficulty of distinguishing between it and certain other microbes. The now well-known methylene blue method of staining has the highest diagnostic value of all. As everyone knows, this, as a valuable aid to the identification of anthrax bacilli in preparations made from the blood, was first described by Sir John M'Fadyean. It consists in staining the smears in a 1-per cent. watery solution of methylene blue, and an essential point in the technique is that the smears must be only lightly fixed. The protoplasmic rod stains blue without undergoing distortion, and the capsule, particularly if it has become swollen, takes on a rose-pink colour. Sometimes the material of the capsule becomes massed, and appears in the preparations as small pink islands; at other times the field of the microscope has a pink, peppery appearance. Even after all the rods have disappeared, one can often find pink masses in a blood smear.

In my Annual Report for 1905 certain observations on guinea pigs dead of anthrax were described, in which the pink reaction was obtained eighty-six hours after death, but was not obtainable 126 hours after death when the body had been opened; and in another guinea pig, which had not been opened a very distinct reaction was obtained in preparations made from the spleen ninety-six hours after death. Since that I have obtained it from scrapings of dried blood from a shed in which the carcase of a cow dead from anthrax had been dressed about a month previously, and I have also obtained it from the spleen of a cow which was exhumed three weeks after death. I do not, however, mean to assert that one can count upon obtaining it at these long intervals after death.

The other aids to diagnosis which one may employ are cultural examination and inoculation. These are methods for the laboratory, but, inasmuch as the laboratory has to depend on the practitioner for material, you will probably desire that I should say something about these methods, and how material should be collected for transmission. When the microscope fails to reveal the presence of anthrax bacilli, or when the material is so grossly contaminated with other microbes that identification of the anthrax bacillus is difficult, inoculation or cultural examination may be resorted to, and it ought to be made use of if the history of the case is suspicious. For inoculation guinea pigs or white mice are usually employed, and one is almost always restricted to the scarification method in order to avoid killing the animals with malignant oedema. Material which is grossly contaminated, or which contains very few anthrax bacilli, sometimes fails to infect by the scarification method, and on this account it seems probable that the cultural method is the more reliable, because the contaminations can be got rid of, and there is no reason to believe that one or two bacilli or spores are not sufficient to start a culture, although they may fail to fatally infect an animal. Agar slopes are inoculated with material from a swab, and placed in the incubator overnight to give any anthrax bacilli which may be present the chance to sporulate. The culture tubes, or material therefrom, are heated in a water bath at 80° C. for half an hour This kills all the non-sporulating bacteria, which are in the majority, and by making cultures on agar slopes from the heated material it is possible to obtain relatively pure or even pure cultures of the anthrax bacillus in a matter of hours. Needless to say, the material sent to the laboratory should be collected as purely as possible.

What is now known as the Strassburg method of collecting material has been strongly recommended by many authorities. In this method pieces of gypsum are soaked in broth, which fills the pores, and they are afterwards sterilized in test tubes and sent out to inspectors. The gypsum is dipped in the suspected material and returned to the laboratory. The theory underlying this method is, that the anthrax bacillus finds the conditions for sporulation in the pores of the gypsum, assuming the temperature to be favourable, and may even have sporulated by the time the

material reaches the laboratory. Under the conditions prevailing in Great Britain, however, the simpler method of sending to the laboratory smears and a swab of sterile cotton-wool which has been soaked in the suspected material meets the case. This is the method in use by the Board of Agriculture, and I have brought with me an apparatus which has been designed for collecting and transmitting material.

Members of this Association will probably be surprised to learn that at this date in the history of a profession which may justly claim to be a scientific profession, there are still men in the position of veterinary inspectors to Local Authorities who are so forgetful of their responsibilities as to send by post, in cigar boxes and other leaky vessels, portions of spleen and other tissues from animals suspected of having died of anthrax. Apart from the moral obligation involved, I think you will agree with me that it would not advance the prestige of the veterinary profession if any one of its members had to answer a charge of contravening the Post Office Regulations in a matter of this kind, or if he were charged with the more serious offence of culpable homicide.

Epizootiology.

The most important factors admitted or suggested to explain the upkeep and dissemination of anthrax are as follows:—

First. The disease is not disseminated to any important extent by the infected animal during life, but it may arise from a patch of infection established by a previous case on a pasture. It is well known that anthrax bacilli may sporulate under certain conditions, and that the spores are very tenacious of life; in the laboratory they may remain infective for several years. One does not know definitely, however, to what extent spore formation may occur in blood, etc., deposited on the pastures under the climatic conditions obtaining in Great Britain, and it must be remembered that for several years past it has been customary to avoid the spilling of blood from animals dead of anthrax. Nor is it known how long the spores of anthrax, granted their formation, may remain capable of infecting after their arrival on the pastures. The available evidence is totally opposed to the view that anthrax arises mainly, or even to a great extent, from previous cases on the same establishment. If it did, one might fairly expect to find the disease frequently repeating itself on the same establishments in the same year and from year to year. This does not happen in Great Britain. The information summarized from the official records clearly shows that the vast majority of outbreaks (average 83·5 per cent.) occur on farms which have not been previously infected, and it is to be noted that it does not necessarily follow that in the remainder (16·5 per cent.) infection arose from virulent material on the pastures, or from a previous case on the same establishment.

By going through the records [for certain counties] of 993 farms infected for the first time during the ten years from 1895

to 1904, I found that anthrax had occurred more than once during that period on 120 farms, that is, on only 12 per cent. of the total.

With regard to the proportion of farms on which anthrax occurred more than once in any one year, the records over a period of twelve years (1895-1906) for the above counties were examined. There were infected for the first time during that period 1,388 farms, and anthrax occurred more than once in any one year on only fifty of them (4·6 per cent.). These figures were published in my Annual Reports for 1905 and 1906, and since then the records for all the other counties of Great Britain have been examined. with practically the same result. In considering the importance of ground infection one must also weigh the fact that, although there have been over 500 outbreaks a year in Great Britain for many years, which must have infected an enormous number of premises, the disease has certainly not increased in proportion, and only a small minority occur on previously infected farms.

Second. It is suggested that the disease is carried by flies.

Many are familiar with the sight of flies feeding on the blood of a carcass which has been opened, and one of the oldest suggestions in relation to infection in the case of anthrax is that it may be carried by flies. In a recent report to the Local Government Board, Dr. Graham-Smith showed that living anthrax bacilli could be recovered from the material which flies regurgitate after feeding, and from their fœces, provided they had fed on anthrax bacilli. Cultures were obtained from the fœces forty-eight hours, and from the crop five days, after feeding. After feeding on spores cultures were obtained up to the twentieth day. This, of course, is not surprising, as we know the spores may live for years. These observations convey the suggestion that flies in the above way disseminate anthrax. I think one must admit that flies could carry infection, but, interesting as Graham-Smith's observations undoubtedly are, there is no important gap in the epizootiology of anthrax which his observations can fill. Further, we have every year a certain number of cases in which men contract anthrax from dressing infected carcases. When this happens it is not those helping, on whom flies may, and do, alight. who contract the disease, but almost invariably it is the man who does the actual cutting, and who has sores on his hands and arms, which come in contact with the blood. Moreover, it is quite obvious (from a table given) that the number of outbreaks in cattle drops very decidedly during the season in which flies are prevalent.

Third. Infection may be carried by contaminated feeding stuffs brought in from countries where anthrax is very prevalent.

The facts . . . . . . are strongly in favour of the view that the great majority of outbreaks in this country are due to infection from without.

Evidence that food stuffs carry infection is very difficult to obtain under the conditions of experimentation, one reason being that the infected portions have probably been consumed

by the dead animal before samples were taken. During the last few years samples of feeding stuffs upon which suspicion rested have been experimentally examined at the Board's laboratory, with negative results. Both Sir John M'Fadyean and Mr. Dunstan, M.R.C.V.S., however, have demonstrated experimentally that cake may contain the spores of anthrax, and the former has isolated the anthrax bacillus from imported oats. These positive results, few as they are, are of the highest importance to the question under discussion, when one considers how enormous are the chances against obtaining them with the small samples it is possible to examine experimentally.

One has next to inquire how feeding stuffs may become contaminated. In the process of manufacture the material from which cake is made is heated to a temperature considerably below the boiling point of water (180 to 200° F.), which is, of course, insufficient to destroy the spores of anthrax. Compound cakes are pressed between metal plates, but the seed from which the other cakes are made is pressed in cloth bags, made from refuse wool and horse hair, to extract the oil. On the assumption that the material used in the manufacture of bagging might infect the cake (shoddy wool and horse hair are frequently infective), about a hundred different samples were examined experimentally at the Board's laboratory, but with negative results. Personally, although I cannot free my mind from the suspicion that bagging may infect cake, I think the most likely explanation of infection is that the grain or meal in course of transit from countries badly infected with anthrax becomes contaminated by infective material from dry hides, which, on account of their light weight, are often stowed on the top of the cargo. I have known a number of outbreaks follow the distribution of a consignment of Soy beans in a part of the country where previously anthrax was almost unknown. It should also be noted that there is a possibility of cake being contaminated by infected material after it leaves the factory.

Fourth. Infection may be disseminated by bone manure, shoddy manure, and refuse from tanneries, which may be put on the land or allowed to contaminate the water-supply.

There is no doubt that the disease is exceptionally prevalent in certain districts where imported hides are tanned and wool is washed, the assumed explanation being that the drinking water becomes contaminated by the sewage from the factories. In the course of enquiry it has also been found that the disease is exceptionally prevalent on certain sewage farms which are known to receive tannery and knackery drainage. With regard to bone manure, I have not obtained evidence that a large number of outbreaks can be accounted for in this way, and it should be noted that most of the bone manure used in this country has been heated, or submitted to a chemical process amounting to disinfection, before it is used on the land. There are outbreaks however, in which the circumstantial evidence indicates that infection has been introduced with turnips which have been grown on land manured with crushed bones. Given infected particles of bone in the soil, one can imagine that roots with the earth adherent might be infective.

Preventive Measures.

In discussing preventive measures in relation to anthrax I would like to take further advantage of the liberty you have accorded to me of limiting discussion on my part to certain features, for it would not be possible to deal with every side of this question without prolonging the paper beyond reasonable bounds, and I feel I have already overstepped the limits of your patience. I would like to restrict myself to preventive and curative inoculation, as the part of the subject which is of more direct interest to practitioners.

The Pasteur method of preventive inoculation has rendered great service in preserving stock on badly infected farms in various parts of the world. The method consists in injecting the animals with fixed doses of attenuated cultures of the *Bacillus anthracis.* Two injections at intervals of twelve days are performed. For the first injection a very attenuated culture is used (first vaccine), and for the second a less attenuated culture (second vaccine) is employed. Immunity is established about twelve to fifteen days after the second vaccine has been injected. It lasts in cattle about a year, and should be repeated after this period. The great majority of cattle operated on show little more than a temporary indisposition with passing fever after the injection, which may be assumed to indicate a slight attack of anthrax, Occasionally, however, an inoculated animal may die of the disease as the result of the injection, and for this reason the animals undergoing the process of immunisation should be kept in a special paddock, or, better still, in sheds which can be disinfected in event of an accident taking place. In sheep, accidents are more frequent. The operation should only be attempted by skilled persons, who will know the best way to prevent accidents, and adopt measures to limit their consequence should they occur.

Since the operation is not altogether unattended by the possibility of loss, and since it incurs a certain amount of expense, one has to consider under what circumstances it will be worth while undertaking it. It will be obvious from the first that on farms registering only one death annually it will hardly be called for, and that it would be folly to adopt it on clean farms.

It results from observations on several millions of cattle in various prrts of the world that accidents occur in about 0·5 per cent. of the inoculated, taken all round, and that the operation may be expected to reduce the death-rate from anthrax on infected farms to about 1 per cent. or slightly under.

If accidents threaten to occur from the inoculation, they can be avoided to a large extent by giving a dose of anti-anthrax serum. The serum is useful both as a preventive and as a curative agent under certain circumstances. The immunity following upon an injection of serum is, of course, quite temporary, but it lasts long enough to tide the animals over certain risks. For example, if an animal has died from anthrax amongst other animals and its blood has been spilt, it is advisable to inject the others with serum, and remove them from the infected place if possible. If it is not possible to remove them, it is

even more desirable to give each a dose of serum to protect them while disinfection is being carried out. The immunity from serum lasts about ten days. When a case of anthrax has occurred from infection by cake or from preventive inoculation with virus for example, and any of the animals in contact show an abnormally high temperature, a dose of serum should be injected. Unless an animal has been very heavily infected, which does not frequently happen in practice, the infection remains local for a long enough period to enable serum to act.

The chances are very much in favour of saving the life of the annual by the use of serum, provided the blood-stream is not yet invaded by the bacilli. Once the blood-stream is invaded, serum is likely to fail.

GRAFTED CACAO AT THE DOMINICA BOTANIC STATION.

BY JOSEPH JONES, Curator, Botanic Station, Dominica.

A large amount of attention has been paid at the Dominica Botanic Station, during the last few years, to the grafting of cacao, and a résumé of the results that were obtained up to July 1909 was given in pamphlet No. 61 of the Department Series, entitled The Grafting of Cacao. These results included the returns from two plots only, and it is the purpose of the present article to amplify them, by means of observations that have been made on five plots of grafted cacao plants, in which the trees range from three to five years old.

In dealing with the record, attention has to be given to the following considerations. In Dominica, the crop year for the varieties of *Theobroma Cacao* ends on June 30; this date has been found to be satisfactory, as the pods of the carême crop have generally all ripened by that date. The end of the crop year for alligator cacao (*Theobroma pentagona*) falls on July 31; this date is not found to be satisfactory, however, especially in the light of the fact that, during the present season, no less than 469 fully grown but unripe pods remained on the forty-five trees under observation, at the end of July. It is evident that this is explained by the slower rates of development and ripening of the pods of Alligator cacao, compared with those of the varieties of *Theobroma Cacao*. Observations have been made at this Station for the purpose of obtaining definite information on this point; namely the time which elapses, in the case of the different kinds, between the stage at which the pod is of the size of a pin's head to that at which it may be picked. These have shown that Alligator cacao pods took 212 days to grow and mature, while the time occupied by Forastero was 184. It may be mentioned that the observations were carried out during a period of very wet weather, in which the duration of sunshine was below the average. On account of this, it is intended to repeat them during the carême season, because it is thought that if the pods are allowed to develop during

a season of dry weather and hot suns, the time taken by them to attain maturity will not be as great as that required under very wet weather conditions. As regards the different varieties of *Theobroma Cacao*—Criollo, Forastero, and Calabacillo—it is probable that, even under identical weather conditions, the times taken by the pods of the different kinds to ripen will vary.

A return must now be made to the main subject of this article; that is to say, the consideration of the yields that have been obtained from several plots of grafted cacao. The particulars in the case of each plot are as follows:—

ALLIGATOR CACAO. The plants are among seedling orange trees, growing at a distance of 20 feet apart: they have been placed both in the rows and between the rows of these, so that the effect has been to obtain a plot of grafted cacao in which the trees of varying ages stand in rows 10 feet apart, and are themselves 20 feet apart in the rows. The slight shade given by the orange trees appears to have been beneficial to the cacao, in its early stages. The results obtained with this species have to be considered in relation to the fact that it is very delicate, and quickly killed by canker—a circumstance that makes it unsuitable for cultivation in Dominica, where only the hardy forms of cacao can be grown successfully. The importance of this consideration is shown by the fact that seventeen out of the sixty-two trees planted in the plot died form the effects of this disease in twelve months—a loss of 26 per cent.

The particulars of the experiment are as follows:—
Plants set out:—

	5	in September 1905.
	12	in November 1905.
	12	in June 1906.
	33	in July 1907.
Total	62	

Annual yield in number of pods:—

176.	to July 31,	1908,	from	7	trees.	Average 25·1
996,	,, ,,	1909,	,,	60	,,	,, 34·3
1,579,	,, ,,	1910,	,,	45	,,	,, 35·0
2,337,	,, ,,	1911.	,,	45	,,	,, 52·0

For the last observation, 469 fully developed, but unripe, pods remained on the trees after its conclusion. If these were counted in the results, the last average yield per tree would be 45·5 pods.

FORASTERO CACAO. (Variety with yellow pods.) This is growing under exactly the same conditions as the plants just described. There are twenty-eight trees altogether, which are divided eqnally between two varieties of yellow-podded Forastero, selected on account of the size and quality of the beans produced by them. The varieties are average bearers, but not as hardy as the red-podded variety, which forms the subject of the observations given below. The plants, however, afford a

striking example, showing the immunity of Forastero cacao to canker disease, for they have all remained healthy since they were planted out; while in the adjoining plot of Alligator cacao, as has been described, the plants are being rapidly destroyed by the disease.

The particulars of the experiment are as follows:—

Plants set out:—

14 in July 1906.
14 in July 1907.

Total 28

Annual yield in number of pods:—

12,	to June 30,	1908,	from	14 trees.	Average	0·8
237,	„ „	1909,	„	14 „	„	16·9
860,	„ „	1910,	„	28 „	„	30·7
1,382,	„	1911.	„	28 „	„	49·3

FORASTERO CACAO. (Variety with red pods, plot I.) This variety was selected on account of its hardiness and good bearing qualities. The plants are growing on a ¼-acre plot that was already established at the time of planting, with twenty-five nutmeg trees set out at a distance of 20 feet apart each way. The cacao plants, which are sixteen in number, are each growing in the middle of the squares formed by the nutmeg trees. It may be mentioned that, during the last season, a commencement was made of grafting from these plants, each one being lightly worked over, and the yield in grafted plants was 600.

The particulars of the experiment are as follows:—

Plants set out:—

16 in August 1906.

Annual yield in number of pods:—

107,	to June 30,	1909,	from	16 trees.	Average	6·7
664,	„ „ „	1910,	„	16 „	„	41·5
693,	„ „ „	1911,	„	16 „	„	43·3

FORASTERO CACAO. (Variety with red pods, plot II.) The plants in this plot are growing among nutmeg trees, exactly in the same way as in plot I. Like these, they will be used later for supplying grafted plants.

The particulars of the experiment are as follows:—

Plants set out:—

16 in October 1907.

Annual yield in number of pods:—

97,	to June 30,	1910,	from	16 trees.	Average	6·0
638	„ „ „	1911,	„	16 „	„	39·9

FORASTERO CACAO. (Variety with red pods, plot III.) On this plot, the plants are growing on ground unoccupied by any other permanent crops. Dwarf bananas and tanias were used for shade, at first; but after twelve months it was thought that the presence of the bananas was retarding the growth of the cacao plants, so that they were cut down, and kept cut down every few weeks, until the underground stems died. In the result, the cacao plants succeeded very well, with tanias only for shade and for covering the ground.

The particulars of the experiment are as follows :—

Plants set out :—

35 in July 1907.
17 in July 1908.

Annual yield in number of pods :—

191,	to June 30, 1910,	from 35 trees.	Average	5·4
893,	„ „ „ 1911,	„ 32 „	„	17·1

It should be pointed out that no special manures have been used on any of the plots on which the above observations were made, nor has the soil been forked. The only treatment given has been a mulching of pen manure or leaves applied during the dry season.

The following table gives the results of the observations that are detailed above:—

Date of planting.	No. of trees planted.	Last date of picking.	No. of bearing trees.	Total annual yield in pods.	Yield per tree in pods.
Alligator cacao:—					
Sept. 1905 ...	5	July 30, 1908	7	176	25·1
Nov. 1905 ...	12	„ 1909	29	996	34·3
June 1906 ...	12	„ 1910	45	1,579	35·0
July 1907 ...	33	„ 1911	45	2,337	52·0
Forastero cacao (yellow pods).					
July 1906 ..	14	June 30, 1908	14	12	0·8
„ 1907 ...	14	„ 1909	14	237	16·9
		„ 1910	28	860	30·7
		„ 1911	28	1,382	49·3
Forastero cacao (red pods, plot 1).					
Aug. 1906 ...	16	June 30, 1909	16	107	6·7
		„ 1910	16	664	41·5
		„ 1911	16	693	43·3
Forastero cacao (red pods, plot 2).					
Oct. 1907 ...	16	June 30, 1910	16	97	6·0
		„ 1911	16	638	39·9
Forastero cacao (red pods, plot 3).					
July 1907 .	35	June 30, 1910	35	191	5·4
„ 1908 ...	17	„ 1911	52	893	17·1

A great deal has been written, during recent years, on the subject of grafting cacao and in connexion with the success that is likely to result from its adoption, and the tendency has been in some cases, to claim too much for the employment of propagation by grafting. The chief utility of grafting is that it may be employed for the purpose of obtaining a large number of different plants of the same variety, with the cer-

tainty that each of these will show the characteristics for which that variety is valued. The means for producing new varieties must be provided by the production of seeds or by the results of bud variation. It seems most likely that progress will be made in this direction by cross-pollinating desirable types of cacao, raising seedlings, and then continuing to obtain plants of the type required by employing grafting, or budding only. The fact that a delicate variety cannot be given the property of hardiness by grafting it upon a more hardy stock is well shown by the behaviour of Alligator cacao on Forastero stocks. The observations already detailed show that such plants, although they grew well and bore excellently, did not exhibit any loss of susceptibility to canker. As a matter of fact, Alligator cacao has proved itself entirely unsuitable for growing under the conditions of Dominica, unless it can be shown that it may be protected from canker by spraying with Bordeaux mixture. Even if this were demonstrated, there are many circumstances that would have to be taken into consideration before this means of controlling the disease could be adopted as a practical measure. Spraying with Bordeaux mixture is an expensive operation requiring skilled labour of a kind that will not be easily obtained in Dominica. There is uncertainty, too, as to the cumulative effect on the soil of repeated spraying with this fungicide, and it is not known but what its use may interfere seriously with the insect life required in cacao pollination, especially in the light of recent investigations that have been made in Dominica, which tend to show that this pollination is effected by plant lice and ants.

It has been made evident that the grafting of selected Forastero varieties on Calabacillo stock has given excellent results. There is little doubt that the employment of this method for propagation would not only give greater yields, but would afford a means of shortening the time of the crop. An additional consideration is that, in forming new plantations, careful selection, with grafting, may prove the soundest method of combating the principal diseases that affect cacao trees.

The selection of cacao by the planter has, up to the present, been confined to those types which have been known for some years as heavy bearers of good cacao, and which have proved resistant to disease. Recent experiments in cross-pollination, carried out at the Dominica Experiment Station, have shown however, that this process is a comparatively easy one ; so that the planter is no longer likely to be confined to known varieties of cacao for grafting. Further, it is probable that the crossing of selected cacaos will result in the production of new varieties possessing greater vigour than those now in cultivation.

It is evident from what has been said, that the breeding of varieties of cacao, on definite lines, might now be undertaken by some of the Agricultural Departments in the West Indies. The period covered by the work would have to be a long one, but the certainty of the ultimate attainment of good results would justify the time spent. This fact forms one of the arguments in favour of the adoption of a continuous policy in regard to such Departments.

It is obvious that the probabilities of obtaining superior crosses with different cacaos are not confined to the varieties of *Theobroma Cacao*. It may be that hardy varieties of these will be crossed with the closely allied Alligator cacao (*Theobroma pentagona*), and that a product will be obtained which possesses the resistant power of the former and some of the good qualities of the latter. So far, it is thought that successful crosses between Forastero and Alligator cacao have been obtained in Dominica. A further possibility of hybridization is that between the common varieties of cacao and *Theobroma bicolor* and *T. angustifolia*, with the object of obtaining new kinds of stocks for grafting or budding. The circumstance that the different species of Theobroma are closely allied and thrive under the same conditions of climate affords encouragement toward such work, and this has already been commenced by experiments with the varieties in Dominica.

Suitable stocks for grafting can only be obtained at present from plants of the hardy Forastero and Calabacillo. Attempts have been made to use seedlings of *T. bicolor* for the provision of stocks, but the union obtained was only temporary. The use of seedlings of the monkey cacao of Nicaragua (*T. angustifolia*) will be tried shortly for the purpose, and if this is successful, this species of Theobroma may prove of value in such work. The aim is to secure material by which a combination of stock and scion may be obtained that will result in great vigour and high productivity.

The grafting of cacao has special importance in relation to attempts to improve the varieties in cultivation by selection. Its practice will give the possibility of the possession by the planter of fields of cacao in which every tree is of the same type, and each pod and bean of a like quality; so that there will be an end to the present unevenness in regard to production, resistance to disease, and value of product. It is hoped, however, by those who wish to see the cacao industry placed on a firm basis, that the feasibility of budding cacao as easily and certainly as this can be done for citrus fruits will be attained eventually, for the following reasons.

Grafting by approach entails a certain amount of additional labour and inconvenience, for the stocks have to be brought near the selected trees, stages have to be erected around the trees for the accommodation of the stocks, and the plants after inarching require daily watering and attention for a period of five to eight weeks, according to the time of the year in which the work is being carried out. In addition, the grafted plants must be kept in a nursery for several weeks, after severance from the parent trees, before they may be planted in the fields. In drawing attention to these difficulties, it is not intended to discourage the adoption of this method of propagating cacao; for even with their existence, grafting by approach is well worthy of adoption If, however, a way is found of budding cacao stocks from nine to twelve months old, growing in bamboo pots in nurseries, the operations connected with propagation would be simplified, the speed of the work would be greater and the latter could be centralized and therefore more easily

carried on. Another consideration in favour of budding is that a tree capable of yielding several hundred shoots for inarching during a season would give, in the same time, thousands of buds; hence the possession of a means of budding cacao would render the propagation of a given variety much more speedy than is at present possible with inarching. The present position as regards the budding of cacao appears to be as follows. Successful experiments in the matter were made some years ago by the officers of the Agricultural Department in Jamaica; but the results as regards the growth and bearing qualities of the budded trees do not appear to have been published. The Curator of the Botanical Garden, Tobago, has achieved success recently in regard to the matter. It is not stated in this case, however, whether the buds were placed on stocks growing in bamboo joints, or on suckers springing from old trees in the field. The Superintendent of Plantations, Bayeux, Hayti, has successfully budded healthy seedling stocks one and a half to two years old growing in the field. Illustrations of the bearing trees appeared in *Tropical Life* for July 1910. Budding on stocks in bamboo pots has resulted in failure in Dominica; though in a few instances, the buds remained alive for several weeks, and made feeble attempts to grow. A renewal of the experiments will be made shortly, it is hoped, under improved conditions. It is suggested that efforts to bud cacao might be made by the Agricultural Departments of the colonies in which cacao is an article of export. If success is to be achieved, it may come more speedily through the efforts made by many workers than as a result of occasional attempts on the part of one or two individuals.

It is expedient, finally, to discuss the propagation of cacao and other plants in its large, practical aspect. Much work has been done during the past twenty-five years, by the Agricultural Departments of the West Indies, in the direction of creating an interest in the raising of new varieties of economic plants, and in the application of the methods of budding and grafting to the propagation of useful plants. The successful production of new varieties of sugar-cane, the substitution of budding in the place of seminal propagation of oranges, grape fruit and other citrus plants may be given as examples; both of these were thought, not many years ago, to be impossible of accomplishment in the West Indies. It is true, in relation to such subjects, that Government Agricultural Departments are able to make experiments, and to show that many plants of economic value, hitherto raised from seeds, may be improved and propagated by other and better methods. It is equally true, however, that such institutions seldom possess either the means or the staff which will enable them to carry on the work to the extent of fully supplying local demands for the specially obtained material.

One of the suggestions sometimes made for remedying this is that estates should possess their own nurseries; but the very specialization that is being attained in methods of propagation precludes the possibility of this in most cases. It would appear therefore, that the natural outcome of the work of the Government Agricultural Departments would be the development of the plant nursery system, which has become so popular in

Europe and the United States, and has done so much to improve the fruit and other plant industries in those parts of the world. When the advances that have been made in agriculture in the West Indies during recent years are considered, it is a matter of surprise that, even in the larger colonies, plant nurseries have been developed to only a small extent. It is almost certain that well-organized nurseries, under private management and directed by men who have received their professional training in European or American nurseries, would find a suitable and profitable field for enterprise in the larger islands, especially in those which possess cheap and simple means for the transport of plants, such as good roads and railways, or costal steamer services. The agricultural interests in such places would benefit greatly by the establishment of nurseries, conducted according to the English and American system, for the regular supply of material for planting standard varieties of economic plants cultivated in these colonies.

THE DETERMINATION OF THE WATER CONTENT OF MOLASSES. AND THE COMPOSITION OF ANTIGUA AND ST. KITTS-NEVIS MOLASSES.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,

Government Analyst and Superintendent of Agriculture for the Leeward Islands.

AND V. M. WEIL, B.Sc.,

Assistant Government Analyst, Antigua.

THE DETERMINATION OF THE WATER CONTENT OF MOLASSES.

In a paper published in the *West Indian Bulletin*, Vol. X, p. 29, by one of us in conjunction with Dr. Francis Watts, C.M.G., the results were given of the analysis of a number of samples of muscovado molasses from Antigua and St. Kitts. In this work the water content was calculated by Heron's formula, according to which $\frac{19}{20} \times 0{\cdot}8$ of the sulphated ash is deducted from the specific gravity of a 10-per cent. solution, that of water being reckoned as 1,000; the resulting figure gives the solution density of the organic total solids exclusive of the ash. From this, the organic total solids are determined by means of Douglas's tables, the results, added to the ash per cent. and subtracted from 100, giving the percentage of water. Mr. R. R. Hall in the same volume of the *West Indian Bulletin* (Vol. X, p. 167) brought forward a series of results which apparently indicate that Heron's formula does not hold good in the case of Barbados vacuum pan molasses, the analytical results adduced showing a difference on the water, as determined by the direct drying and by calculation by means of the above formula, amounting in some cases to as much as 4·5 per cent.

In the original paper quoted above, two determinations by direct drying showed in one case a very close agreement with the water calculated by Heron's formula, and in the other a divergence of 2·4 per cent.

Experimental Details and Results.

In view of the results found by R. R. Hall, it becomes a matter of importance to test how far Heron's formula may be expected to hold good, and in consequence a series of further determinations of water in molasses was made by two methods A number of samples from the sugar crop of 1911 were obtained from estates in Antigua, and on them were determined: the water by direct drying; the specific gravity of a 10-per cent. solution by means of a Sprengel tube, the determination being made at 30°C. and compared with water at 16·6°C.; and the ash by sulphation and ignition at a low red heat, the actual ash being calculated by multiplying the sulphated ash by 0·95. To complete the analyses the sucrose was determined, by inversion by the Clerget process, and the glucose by titration of a 10-per cent. solution against Fehling's solution, using the method described by one of us, in conjunction with Dr. Watts, in the *Journal of the Society of Chemical Industry*, Vol. XXVII, p. 191.

In addition, the refractive index of each of the samples was determined in an Abbé refractometer, and the water content calculated therefrom by means of Prinsen Geerligs's tables.

It may here be pointed out that the drying of the samples of viscous saccharine liquids presents considerable difficulties. If, as is usually the case, it is conducted on sand at a temperature of 98°C., there is difficulty in removing the last traces of moisture, even though the operation be conducted in one of the various forms of vacuum oven, in which the drying can be carried out under reduced pressure. If, on the other hand, the temperature is raised above 100°C., there is a considerable risk of decomposition of the organic compounds present.

In the series of results here reported, the drying was conducted on a measured quantity of a 10-per cent. solution of the sample, on a coil of filter paper at 98°C., in a slow current of dry air under reduced pressure. A specially devised piece of apparatus was employed for the purpose; this is described at the end of the paper, and an illustration of the apparatus is also given.

In all, seven samples were examined. The results of the determination of the water content by the various methods and the actual composition of the different samples are given in the tables below :—

TABLE I.

DETERMINATION OF WATER CONTENT.

	1	2	3	4	5	6	7
	Water, per cent.	Water, per cent.	Water, per cent.	Water, per cent.	Water, per cent.	Water, per cent.	Water, per cent.
By direct drying	25·5	29·3	28·0	28·8	28·6	25·1	23·6
Calculated by Heron's formula	26·9	29·6	28·3	28·9	29·3	25·4	24·0
Brix	22·8	25·4	23·0	24·9	25·4	20·2	15·6
Calculated from refractive index	25·4	28·6	26·0	26·8	27·8	24·1	21·6
Calculated from R. R. Hall's formula ...	26·1	29·0	27·0	28·3	28·8	25·9	24·1

TABLE II.

COMPOSITION OF THE SAMPLES.

	1	2	3	4	5	6	7
Water	25·5	29·3	28·0	28·8	28·6	25·1	23·6
Sucrose... ..	58·8	56·9	57·2	57·3	57·0	41·3*	32·0*
Glucose... ...	6·0	4·5	4·8	5·2	5·1	17·2	20·9
Ash	3·8	3·7	4·7	3·6	4·0	4·7	7·5
Non-sugar ...	5·9	5·6	5·3	5·1	5·3	11·7	23·6

*Sugar calculated from the direct polarization and the invert sugar content of the samples.

Nos. 1 to 5 were muscovado molasses; No. 6 was first vacuum pan molasses: No. 7 was a second vacuum pan molasses; all taken from estates in Antigua during the crop of 1911.

It will be seen that in all cases the water as determined by direct drying is in close agreement with that calculated by Heron's formula; the widest divergence is in the case of No. 1 and amounts to 1·4 per cent.; in no cases are the divergences found which are exhibited in the case of Mr. Hall's experiments.

The results appear to demonstrate clearly the reliability of the formula when applied to a variety of descriptions of molasses in Antigua. It may be added that the experience of other workers, in England, has clearly shown the applicability of the formula to a large variety of sugar house products.

An interesting comparison is that given between the water content as determined by direct drying, and its value as shown by the refractive index, in accordance with the method of Prinsen Geerligs, Tolman and Smith, and H. Main.

It will be seen that in the above results the two values are in fairly close agreement but not so close as that given by Heron's formula.

In the paper referred to above, Mr. Hall introduces the use of a factor for calculating the water content, based on the ratio borne by the total solids other than sugar as determined by actual analysis to the apparent total solids other than sugar, as given by the difference between the sum of sucrose and glucose and the Brix of the molasses.

To calculate the water in a sample of molasses, the apparent total solids other than sugar is multiplied by it: the sum of this product and the sucrose and glucose contents when deducted from 100 gives the water by difference.

Following this method, the corresponding ratio has been calculated in the above series of results and found to have a mean value of 0·73, and the water content of each of the above samples calculated by means of it. The results are given in the bottom line of Table I; it will be seen that they are in very close agreement with the actually determined values and with the results as calculated by Heron's formula. When Mr. Hall's factor, 0·78,* is employed, the agreement is not so close, though the divergences shown are not very large: for comparison they are given below:—

1	2	3	4	5	6	7
25·4	28·3	26·3	27·7	28·2	24·8	22·5

The use of a factor of this description is likely to be of value when the ratio of the organic non-sugar content to the ash content does not vary very widely, and when the composition of the ash is fairly constant. If these quantities vary

*In the case of Mr. Hall's results, the mean value of this factor is 0·78.

much, divergencies from accuracy may be expected to occur, since, as a rule the density concentration curves for soluble ash constituents differ very markedly from similar curves for organic solids of a saccharine character.

To summarize the results arrived at :—

(1) The determination of water in sugar house products is a matter of difficulty requiring special precautions to ensure accuracy.

(2) Actual determination of the water content of molasses by direct drying appears to demonstrate the applicability of Heron's formula for calculating the water in sugar house products to the various classes of molasses met with in Antigua ; this is in accord with the experience of workers elsewhere in relation to a variety of such products.

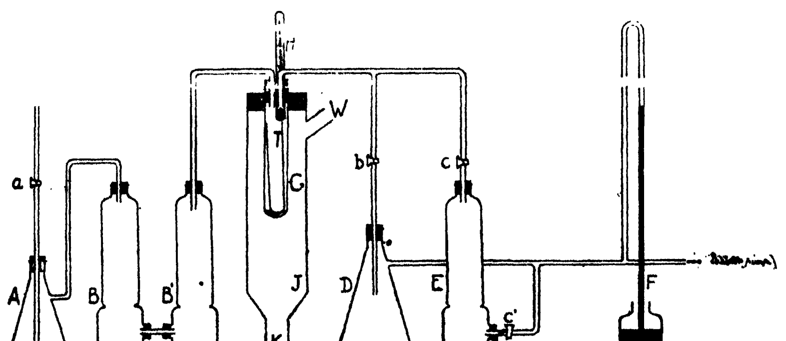
(Heron's formula appears to give results more nearly approaching accuracy than do those obtained from the reading of the refractometer.)

(4) The formula suggested by Mr. Hall, whereby the apparent non-sugars are multiplied by 0·78 to give the true non-sugars, and thence the water content, gives results approximating moderately well to actually determined values, but would appear likely to be subject to error owing to variations in the composition of different samples.

Description of the Apparatus Used for Drying Samples of Molasses.

The apparatus used for conducting the moisture determination in these experiments is a modification of that devised by Thorne and Jeffers for the purpose of estimating the water contents of invert sugar syrups.

DIAGRAM OF APPARATUS USED IN THE DETERMINATION OF WATER IN MOLASSES



The apparatus is shown in the diagram. The principle underlying its construction is that the drying is conducted at a temperature of 98° C. in a slow current of dry air under reduced pressure ; by this means the complete desiccation of the sample is ensured, the moisture being removed as it is liberated, and the likelihood of re-absorption minimized.

In the diagram, G represents the actual drying chamber. It consists of a stout glass tube, contained in a steam jacket, J, of block tin, which is attached to a steam generator at K and to a Soxhlet ball condenser at W ; the steam generator and the condenser are not shown in the diagram. The drying chamber is fitted with a thermometer and is connected on the one side with a series of drying vessels A, B and B′ and on the other side with a water vacuum pump and mercury vacuum gauge, alternative connexion to which is afforded through a trap flask, D, or through a shunt containing the calcium chloride tower, E.

Of the drying vessels A, B, and B′, A is a wash bottle containing sulphuric acid, fitted with a tap, a ; this bottle serves to regulate the pressure and the velocity of flow of air through the apparatus ; the rate at which the air bubbles through the acid serving to indicate the rate of flow. The towers B and B′ are filled with calcium chloride.

The drying is conducted on a coil of filter paper; in our experiments, Carl Schleicher and Schull's No. 597 was found to answer very well, but any paper with a fairly high absorptive power would probably be suitable. In making a determination, a strip of this paper 58 cm. long by 9 cm. wide is rolled into a tight coil and placed inside a weighing tube (T) 12 cm. in length and 2 cm. in diameter, carrying a very closely fitting stopper. The stopper is removed and the tube and coil introduced into the drying chamber, G, of the apparatus. The steam generator and vacuum pump are started, and a current of air under a vacuum of 550 to 600 mm. is drawn through the apparatus. The temperature in the drying chamber under thes econditions was found to average 98° C., with very little variation. In the preliminary drying, the tap b is kept shut and the taps c and c′ open, the air current passing through the calcium chloride tower E. The object of this third tower is to prevent any re-absorption of water vapour by the coil, through back diffusion from the pump; it was found that unless this precaution was taken it was impossible to free the tubes leading from the drying chamber to the pump from the last traces of moisture. At the end of four hours, the preliminary drying of the filter paper coil is complete. The vacuum is then broken, the stopper immediately inserted in the tube T and the tube and coil allowed to cool in a desiccator and weighed. Ten cubic centimetres, of a 10-per cent. solution of the molasses under examination is then introduced on the dried coil, the tube and coil are replaced in the drier and the desiccation resumed. During the earlier stages of the drying the taps c and c′ are closed while b is kept open, the trap D serving to collect the bulk of the moisture as it distils from the coil. As soon as the sample is approximately dry, as adjudged by the disappearance of moisture in the lead tube, the tap b is shut and c and c′ are opened and the drying completed in the same way as that in the case of the preliminary drying of the coil.

It was found that eight hours' drying in this way is sufficient to remove the last traces of moisture and to reduce the coil to constant weight.

The apparatus gives very satisfactory and concordant results, and with the exception of the alteration of the taps b c and c′ toward the completion of the operation, requires practically no attention, once the drying of a sample has been commenced.

THE COMPOSITION OF ANTIGUA AND ST. KITTS-NEVIS MUSCOVADO MOLASSES.

The foregoing paper contains analyses which supplement existing information concerning the muscovado molasses of Antigua. A number of additional analyses of muscovado molasses from St. Kitts, Nevis and Antigua were performed during the year 1910 at the Government Laboratory for the Leeward Islands. These, with those already quoted in the preceding paper, are given in tabular form below; together, they constitute a useful addition to the analyses given in the *West Indian Bulletin*, Vol. X., p. 29.

	1	2	3	4	5	6	7	8	9	10
Sucrose ...	58·8	56·9	57·2	57·3	57·0	53·2	54·3	45·9	55·9	47·5
Glucose ...	6·0	4·5	4·8	5·2	5·1	11·6	12·7	14·0	7·5	15·0
Non-sugar	5·9	5·6	5·3	5·1	5·3	4·5	6·2	8·0	4·1	3·5
Ash ...	3·8	3·7	4·7	3·6	4·0	3·5	3·0	3·7	4·0	4·0
Water ..	25·5	29·3	28·0	28·8	28·6	27·2	23·8	28·4	28·5	30·0
	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Numbers 1 to 5 are the Antigua muscovado molasses of which the composition has already been given; the figures are reproduced again for convenience of reference; No. 6 is also an Antigua sample; No. 7 is a St. Kitts sample; No. 8 is a reboiled muscovado molasses, also from St. Kitts; while Nos. 9 and 10 are from Nevis.

The additional information here given bears out the conclusion arrived at in the first part of the paper, namely that St. Kitts muscovado molasses contain somewhat less sucrose than those of Antigua

(Pages 1 to 95 issued January 15, 1912.)

WEST INDIAN AGRICULTURAL CONFERENCE, 1912.

The greater number of the representatives at the West Indian Agricultural Conference, 1912, arrived at Port-of-Spain, Trinidad, on Tuesday, January 23, by steamships of the Royal Mail Steam Packet Company and the Royal Dutch West India Mail Company. They were met on arrival by members of the local Organizing and Reception Committee, appointed by the Agricultural Society of Trinidad and Tobago, which included the Colonial Secretary, the Hon. S. W. Knaggs, C.M.G.; the Director of Agriculture, Professor P. Carmody, F.I.C., F.C.S.; the Hon. G. T. Fenwick, C.M.G.; the Hon. C. de Verteuil; the Rev. T. Morton, D.D.; Messrs. J. B. Rorer and E. Tripp; the Hon. Adam Smith; Lieut.-Colonel Collens, W. Burslem, Captain M. Short, H. Hoffmann, E. C. Skinner and W. G. Freeman (Secretary).

The Conference was opened at 1.30 p.m. on the same day at the Victoria Institute, Port-of-Spain, under the presidency of Dr. Francis Watts, C.M.G., Imperial Commissioner of Agriculture for the West Indies, by His Excellency the Governor, Sir George Ruthven Le Hunte, G.C.M.G. At the opening ceremony, the delegates were present, including His Lordship the Bishop of Barbados, the Right Reverend W. P. Swaby, D.D.; the Administrator of St. Lucia, His Honour E. J. Cameron, C.M.G.; the Colonial Secretary of Barbados, Major the Hon. J. A. Burdon, C.M.G.; the Speaker of the House of Assembly, Barbados, the Hon. Sir Frederick Clarke, K.C.M.G.; the Acting Colonial Secretary of the Leeward Islands, the Hon. Edward B. Jarvis; and Lieut.-Colonel F. C. Trollope. On the platform were the Governor, Dr. Watts, His Grace the Archbishop of Port-of-Spain (Dr. Dowling, O.P.), His Lordship the Bishop of Trinidad (Dr. Welch, M.A.), Professor Carmody, Hon. Lieut.-Colonel G. D. Swain, Hon. Adam Smith, Hon. H. A. Alcazar, K.C., Hon. Dr. E. Prada, Hon. Dr. S. M. Laurence and Captain A. C. Boddam-Whetham, A.D.C. to the Governor. There were also present Lady Clarke, Mrs. J. A. Burdon, Mr. and Mrs. Freeman,

Mrs. McCarthy, Monsignor de Martini, Mr. C. P. David, Mr. C. C. Stollmeyer, Dr. H. L. and Mrs. Clare, and a representative gathering of officials, planters and the commercial community.

The following is the list of representatives and visitors at the Conference :—

BRITISH DELEGATES.

The Representative of the Royal Botanic Gardens, Kew (A. W. HILL, ESQ., M.A., F.L.S., Assistant Director).

The Representative of the Committee of Entomological Research (GUY A. K. MARSHALL, ESQ., Scientific Secretary).

The Representatives of the British Cotton Growing Association :—

J. W. MCCONNEL, ESQ.

W. MARSLAND, ESQ.

The Representatives of the West India Committee :—

C. SANDBACH PARKER, ESQ.

E. R. DAVSON, ESQ.

JAMAICA.

The Representative of the Agricultural Society (DUGALD CAMPBELL, ESQ.).

BRITISH GUIANA.

The Representatives of the Board of Agriculture :—

Professor J. B. HARRISON, C.M.G., M.A., F.I.C., etc., Director of the Department of Science and Agriculture, Chairman of the Board of Agriculture and Chairman of the Board of Education.

The Hon. B. HOWELL JONES, C.M.G.

The Representatives of the Department of Science and Agriculture :—

The Science Lecturer (ALLEYNE LEECHMAN, ESQ., F.C.S.).

The Economic Biologist (G. E. BODKIN, ESQ., B.A.).

The Superintendent, Onderneeming School Farm (S. H. BAYLEY, ESQ.).

The Head Gardener (J. F. WABY, ESQ., F.L.S.).

The Representative of the Royal Agricultural and Commercial Society (J. J. NUNAN, ESQ., B.A., LL.B., President).

The Representative of the Planters' Association (The Hon. B. HOWELL JONES, C.M.G.).

The Representative of the Chamber of Commerce :—

The Hon. C. G. A. WYATT, (President).

W. DOUGLAS, ESQ., F.I.C., F.C.S.

TRINIDAD AND TOBAGO.

The Director of Agriculture and Vice-President of the Board of Agriculture (Professor P. CARMODY, F.I.C., F.C.S.).

The Assistant Director of Agriculture (W. G. FREEMAN, ESQ., B.SC., A.R.C.S., F.L.S.).

The Assistant Analyst and Science Master (C. H. WRIGHT, ESQ., B.A., F.I.C., F.C.S.).

The Assistant Analyst (H. S. SHREWSBURY, ESQ., F.I.C.).

The Assistant Analyst (JOSEPH DE VERTEUIL, ESQ., F.C.S.).
The Assistant Analyst and Lecturer on Botany (A. E. COLLENS, ESQ., F.C.S.).
The Assistant Superintendent and Curator, Royal Botanic Gardens, Trinidad (F. EVANS, ESQ.).
The Government Veterinary Surgeon (J. DUNCAN MILLER, ESQ.).
The Curator, Botanic Station, Tobago (W. E. BROADWAY, ESQ.).
The Manager of the Government Stock Farm (J. MCINROY, ESQ.).
The Manager, Tobago Stock Farm (H. MEADEN, ESQ.).
The Manager, St. Augustine Estate (J. C. AUGUSTUS, ESQ.).
The Representatives of the Board of Agriculture :—
The Hon. S. HENDERSON.
NORMAN LAMONT, ESQ.
The Mycologist (J. BIRCH RORER, ESQ., A.B., M.A.).
The Entomologist (F. W. URICH, ESQ., F.E.S, C.M.Z.S.).
The Assistant Entomologist (P. L. GUPPY, ESQ, F.E.S.).
The Inspector of Schools (Lieut.-Colonel J. H. COLLENS, V.D.).
The Principal, Queen's Royal College (W. BURSLEM, ESQ., M.A.)
The Principal, St. Mary's College (Very Revd. Dr. E. A. CREHAN).
The Forest Officer (C. S. ROGERS, ESQ.).
The Representatives of the Agricultural Society :—
The Revd. Dr. MORTON (Vice President.).
H. WARNER, ESQ.
JAS. ARBUCKLE, ESQ.
Dr. A. FREDHOLM.
The Representatives of the Chamber of Commerce :—
W. GORDON-GORDON, ESQ.
J. H. SMITH, ESQ.
The Representative of the Permanent Exhibition Committee :—
HUGO HOFFMAN, ESQ.
The Representative of the Tobago Planters' Association :—
THOMAS THORNTON, ESQ., A.R.C.S.

BARBADOS.

The President of the Education Board :—
His Lordship the Bishop of Barbados (The Right Revd. W. P. SWABY, D.D.).
The Colonial Secretary (Major the Hon. J. A. BURDON, C.M.G.).
The Superintendent of Agriculture (J. R. BOVELL, ESQ., I.S.O., F.L.S., F.C.S.).
F. A. C. COLLYMORE, ESQ., M.C.P.
The Representatives of the Agricultural Society :—
The Hon. Sir F. J. CLARKE, K.C.M.G., President.
Lieutenant-Colonel F. C. TROLLOPE.
E. A. ROBINSON, ESQ.
W. D. SHEPHERD, ESQ.
J. L. SHANNON, ESQ., D.V.M.

WINDWARD ISLANDS.

The Superintendent of Agriculture, Grenada (G. G. AUCHINLECK, ESQ., B.SC.).
The Representatives of the Grenada Agricultural and Commercial Society :—
His Honour R. S. JOHNSTONE, M.A., Chief Justice.

The Hon. D. S. DE FREITAS, President of the Society.
The Hon. G. S. SETON-BROWNE, a Vice-President.
JOHN BARCLAY, ESQ.
G. KENT, ESQ.

The Head Master of the Grenada Boy's Secondary School (D. HEDOG JONES, ESQ., B.A., B.SC.).
The Agricultural Superintendent, St. Vincent (W. N. SANDS, ESQ.).
The Representative of the St. Vincent Agricultural and Commercial Society :—
The Hon. J. G. W. HAZELL (Chairman).
The Administrator of St. Lucia (His Honour E. J. CAMERON, C.M.G.).
The Agricultural Superintendent, St. Lucia (J. C. MOORE, ESQ.).
The Assistant Agricultural Superintendent, St. Lucia (A. J. BROOKS, ESQ.).
The Representative of the St. Lucia Agricultural Society (GEO. BARNARD, ESQ.).

LEEWARD ISLANDS.

The Representative of the Colony of the Leeward Islands (The Hon. EDWARD B. JARVIS, Acting Colonial Secretary).
The Government Chemist and Superintendent of Agriculture (H. A. TEMPANY, ESQ., B Sc., F.I.C., F.C.S.).
The Curator, Botanic Station, Antigua (T. JACKSON, ESQ.)
The Representative of the Antigua Agricultural and Commercial Society (A. P. COWLEY, ESQ.).
The Curator, Botanic Station, Dominica (JOSEPH JONES, ESQ.).
The Representative of the Dominica Planters' Association (F. E. EVERINGTON, ESQ.).
The Agricultural Superintendent, St. Kitts (F. R. SHEPHERD, ESQ.).
The Head Master, St. Kitts Grammar School (W. H. MITCHELL, ESQ., M.A.).
The Representative of the Agricultural and Commercial Society, St. Kitts (J. R. YEARWOOD, ESQ.).
The Representative of the Agricultural and Commercial Society, Nevis (The Hon. J. S. HOLLINGS.)
The Curator of the Botanic Station. Montserrat (W. ROBSON, ESQ.).
A. J. MORLAND, ESQ., Montserrat.
The Agricultural Instructor, Virgin Islands (W. C. FISHLOCK, ESQ.).

DUTCH GUIANA.

The Director of Agriculture (Dr. P. J. S. CRAMER).

OFFICERS OF THE IMPERIAL DEPARTMENT OF AGRICULTURE FOR THE WEST INDIES.

The Imperial Commissioner of Agriculture for the West Indies (Dr. FRANCIS WATTS, C.M.G., etc.).
The Scientific Assistant (A. H. KIRBY, ESQ., B.A.).

The Entomologist (H. A. BALLOU, ESQ. M.SC.).
The Mycologist (F. W. SOUTH, ESQ. B.A.).
The Veterinary Officer (P. T. SAUNDERS, ESQ., M.R.C.V.S.).

Honorary Secretaries to the Conference	A. H. KIRBY, ESQ., B.A. A. G. HOWELL, ESQ.
Assistant Secretary,	M. B. CONNELL, ESQ.

HONORARY MEMBER.

H. C. PEARSON, ESQ., Editor, *India Rubber World*.

VISITORS.

S. SIMPSON, ESQ., formerly Science Lecturer in Agriculture to the Egyptian Government Agricultural College.

W. STRICKLAND, ESQ., and G. RUTHERFORD, ESQ., Carnegie Scholars in Entomology, connected with the Entomological Research Committee.

J. C. HUTSON, ESQ., Student in Entomology in the Imperial Department of Agriculture.

G. N. SAHASRABUDDHE, ESQ., Indian Research Student.

E. ESSED, ESQ.

The following programme of proceedings and excursions was arranged for the Conference :—

Tuesday. January 23.

1.30 p.m. to 4 p.m.—Opening of Conference at the Victoria Institute.
President's Address.
Agricultural Progress in Trinidad and Tobago by Professor P. Carmody.

4.30 p.m.—Reception at Government House by His Excellency the Governor, and Garden Party.

8.30 p.m.—At the Victoria Institute. (1)—Address on Colour Photography.—Mr. J. B. Rorer, A.B., M.A.
(2)—Notes on some Agricultural Activities in Trinidad.—Mr. W. G. Freeman, B.Sc.
(Both illustrated with lantern slides.)

Wednesday, January 24.

7.30 a.m. to 8.30 a.m.—At St. Clair Experiment Station.—Cacao Demonstration. Methods of trapping Cacao Beetles.—Mr. P. L. Guppy.

Methods of spraying Cacao.—Mr. J. B. Rorer, A.B., M.A.

9 a.m. to 12 noon.—Session of Conference at the Victoria Institute. Papers and discussions relating to Cacao and Forestry.

1.20 p.m. to 4 p.m.—Session of Conference at the Victoria Institute. Papers and discussions relating to Sugar.

Thursday, January 25.

7.15 a.m.—Visit to the Tram Car system and workshops by kind invitation of the Company. Special Cars leave Queen's Park Hotel at 7.10 a.m.

9 a.m. to 12 noon.—Session of Conference at the Victoria Institute. Papers and discussions relating to Plant Diseases and Pests, Cocoa-nut, Lime and Fruit industries.

Afternoon—Alternative excursions.

(*a*) River Estate.
(*b*) To Cacao Estates in Santa Cruz Valley.
(*c*) Visits to Educational Institutions in Port-of-Spain.

Friday, January 26.—All day excursion to the Oil Fields at Guapo, by kind invitation of the Hon. Thomas Cochrane.

8.30 p.m.—At Victoria Institute. Address on Rubber Cultivation, illustrated by lantern slides, by Dr. Cramer and others.

Saturday, January 27.

8 a.m. to 11 a.m.—Session of Conference at Victoria Institute. Papers and discussions relating to Cotton.

12.30 p.m. to 3 p.m.—Session of Conference at Victoria Institute. Papers and discussions relating to Agricultural Education.

3.15 p.m.—Visit to St. Augustine Estate and Government Farm.

7.30 p.m.—Conference Dinner.

Sunday, January 28.—Afternoon excursion to the islands near the Bocas, Floating Dock, etc., by kind invitation of the Royal Mail Steam Packet Company.

Monday, January 29.

7.30 a.m. to 8.30 a.m.—St. Clair Experiment Station. Demonstration of matters relating to Rubber.

9 a. m. to 12 noon—Session of Conference at the Victoria Institute. Papers and discussions relating to Rubber.

Afternoon—Attendance at Private View and Opening Ceremony of Agricultural and Industrial Exhibition, by kind invitation of the Trinidad and Tobago Agricultural Society.

Tuesday, January 30.

9 a.m. to 12 noon.—Session of Conference at the Victoria Institute. Subjects for discussion: The proposal for a West Indian Trade Commissioner in Canada. The work of the Entomological Research Committee.
Closing of the Conference.

In opening the Conference, HIS EXCELLENCY gave the following address:—

Mr. President, Your Grace, My Lords, Your Honours, Ladies and Gentlemen. In opening the eighth West Indian Agricultural Conference, which I am very happy to say, is being held here in Trinidad this week, I have to bid the delegates a very hearty welcome. We are delighted to see you in Trinidad and hope you will find your stay, which I am sure Trinidad will

regard as being only too short, a very pleasant and profitable one. (Applause.) We especially welcome the delegates who are here from the Old Country—from Home (cheers)—at the sacrifice of much time, because we know how valuable their time is, not only to themselves but to everybody else there; they have come all the way from England, and we give them a special welcome. We also welcome the representatives from the neighbouring foreign colonies, and as a British Governor I beg to tender my very sincerest welcome to them here. (Applause.) And to our friends from neighbouring West Indian Colonies I beg to tender also a most hearty welcome. Some of them, I am glad to know, are old West Indian friends of mine, and that lends an additional personal pleasure to me to-day. You have a busy time before you, and this afternoon's proceedings include the President's Address and an address by the Director of Agriculture (Professor Carmody), so that I do not intend to take up more than a few minutes of your time here. I am sorry for one thing: that though the delegates have arrived at a time when Trinidad is specially pleasurable on account of our cool, dry season, it is not the best season for our planters, and you will find our great cacao and sugar industries somewhat at a disadvantage, compared with what they would be if you had hot and steamy weather. But you will learn one lesson, and that is, that the Trinidadian never knows what it is to be beaten; he never loses heart; and if he has a bad season one year, does not complain about it but looks forward to a good and a better one next year. I hope we shall have this beautiful King's weather all the while you are here: though at the same time you will not have an opportunity of seeing Trinidad's cultivation at the very best. I especially commend to you a most useful little publication for which we are indebted to the Assistant Director of Agriculture, Mr. W. G Freeman, who has compiled a handy little book which will give you all the information about the colony you are visiting. I hope you will have every opportunity of seeing everything. You have a long programme of work, with intervals for pleasure and recreation and visits. I regret very much that owing to slight indisposition my friend, Mr. Cochrane, is not able to be present this afternoon. He was coming with me, but with great regret was unable to do so. In his absence—I should not have referred to it if he were present—I am sure the whole Conference will feel very indebted to him for the generous arrangements he has made for Friday next, in having chartered one of the Intercolonial Steamships to take us over to see one of the oil fields at Point Fortin. (Cheers.) I hope it will be a most interesting and new experience to all those whose knowledge of the West Indies hitherto has been confined to agricultural productions. You will have an opportunity of seeing the work of one of our oil companies in full swing; the beginning of work which, I hope, will be not only of benefit to us in Trinidad, but will also be an Imperial benefit. If our hopes and those of experts are realized, Trinidad will become a valuable asset as an oil producer; and, I say, you will have an opportunity of seeing some of the oil works in progress.

Before you leave here, you will, I hope, join us in the opening of our Agricultural Show, which takes place before you leave and will be continued during the following week. I think you will find there a great deal to interest you, and we shall welcome you all there on the opening day. I do not think I will take up your time and that of the President any longer, but merely repeat what a pleasure it is to welcome you here, and wish that the Conference will be the very successful one that I know it will be. I hope you will have a very pleasant and happy time during your visit here. (Applause.) And now, in formally declaring this Eighth Agricultural Conference open, I will ask the President to deliver his Presidential Address. (Applause.)

THE PRESIDENTIAL ADDRESS.

Dr. FRANCIS WATTS then rose and said:—Your Grace, My Lords, Your Honours, Ladies and Gentlemen: I desire most sincerely to thank Your Excellency and the Colony of Trinidad for the cordial welcome you have extended to the delegates to this West Indian Agricultural Conference, and for all the careful and well planned arrangements that have been made for facilitating the work of the Conference and for the comfort and entertainment of those attending it. Of the cordiality of Your Excellency's welcome I have already ample evidence, but for a full appreciation of all that Your Excellency and the Colony are doing for the furtherance of our objects, it will be necessary to await the events of this week; and I am well assured from what I have already seen, that the grateful appreciation of the delegates to this Conference will be proved from day to day.

These Agricultural Conferences, of which the present is the eighth of the kind that have been held in the West Indies, are recognized as being of considerable importance in affording an interchange of thought in many directions and on many subjects. Among such subjects are included: the relationship of the various Governments to agricultural affairs; the aim and objects of the Departments of Agriculture that now exist throughout the West Indies and British Guiana; the relationship of the planters to the scientific workers; the state and progress of the various industries; and the question of the training and educating, in their various grades, those who are to occupy themselves in those industries. Judging from the interest that has been taken in this present Conference, I feel confident that it will fully maintain the reputation for value and usefulness established by the Conferences of the past.

The interest of this Conference has been widened in that we now have present, for the first time, regular delegates from British institutions interested in West Indian affairs. I believe that this innovation will prove extremely useful, and that the delegates from the West Indies and British Guiana will welcome the addition to our ranks.

Four years have elapsed since the holding of the last Conference—a longer interval of time than has occurred between former Conferences. This is a circumstance, however, which should have afforded opportunity for the accumulation of

a large number of facts of value and importance in connexion with the varied industries and diverse interests of the Colonies represented here.

In referring to the interval since our last Conference and to the events that have taken place therein I must, before proceeding further, allude to one event that has profoundly influenced us as loyal Colonists; I refer to the lamented death of His late Majesty King Edward VII, which occurred with almost tragic suddenness on May 6, 1910, whereby the nation lost a ruler whose sagacity and wise guidance were rapidly becoming more and more appreciated and valued, and one who had deservedly attained the highest place in his people's affection. His late Majesty evinced great interest in agricultural developments, and was earnest in his desire to promote these throughout his wide dominions.

While we lament the death of King Edward, we proclaim most dutifully and in all sincerity our allegiance to his illustrious successor His Majesty King George V, a sailor King, who has visited these Colonies represented here to-day, and whose knowledge of his Dominions Beyond the Seas is unrivalled amongst Princes. Already overwhelming testimony of the loving regard in which His Majesty and the Queen Consort are held by their people has been shown during the brilliant events attending Their Majesties' Coronation and the more recent splendours of the Indian Durbar.

The former Conferences were presided over by Sir Daniel Morris, K.C.M.G., to whom they owed their origin, and to whose untiring energy the West Indian Colonies lie under deep obligation; to those assembled at this gathering, Sir Daniel has requested me to convey a cordial message, wishing us all success in our undertaking, and trusting that the Agricultural Conference of 1912 will be as successful and as beneficial to the West Indies as any of its predecessors. Since the holding of the last Conference Sir Daniel has relinquished the office of Imperial Commissioner of Agriculture, leaving behind him a record of which any public officer may well be proud. In giving up these duties, Sir Daniel has by no means ceased to take an active part in West Indian matters, for, in his capacity as Adviser to the Colonial Office, he maintains a close association with West Indian affairs: while as a member of the Royal Commission on Trade relations between Canada and the West Indies, he has recently visited the scenes of his former labours and has played a prominent part in doing a most useful piece of work, the full bearing and importance of which will be appreciated increasingly as time goes on.

The Commission referred to was appointed in August 1909. It visited Canada in September of the same year and the West Indies in February 1910, while its Report was dated August 19, 1910. Now that events in Canada have assumed a phase that permits of more attention being given to matters pertaining to trade with the West Indies, it is probable that in the near future a considerable amount of interest will be taken in the information collected by the Royal Commission and in the Report thereon.

This Report constitutes a valuable summing up of the conditions pertaining to, and affecting, trade between the countries concerned, and leaves no doubt of the value to the West Indies of close relationship with the Dominion. It is clear to most that the stability of the sugar industry of British Guiana and the West Indies will be best assured by maintaining a hold upon the Canadian market, and that the loss of this market cannot be regarded without considerable concern. In this connexion I have not seen much stress laid upon the view that the production of sugar in countries belonging to and associated with the United States is rapidly increasing and bids fair to overtake the demand. When this occurs, the United States will become a sugar-exporting country, and at this stage West Indian sugar may be in a disadvantageous position in Canada unless it has the advantage of preferential treatment.

Other aspects of the conditions affecting the European sugar question lead me to think that enhanced stability and considerable benefit to the West Indian sugar industry may be derived from a settlement of the question of reciprocal trade relations with Canada, whereby British West Indian sugar may receive preferential treatment in the Canadian market. If I read rightly the signs of the times, the matter was never of greater moment to the West Indies than it is now. The consideration of the question, however, lies beyond the scope of this Conference.

The important announcement has been made recently that the further discussion of the proposals for reciprocity between the Dominion of Canada and the West Indies is to form the subject of a Conference of representatives of the Governments concerned, at the earliest convenient opportunity: if possible in March next. The holding of such a Conference will constitute an event of great moment to the West Indian Colonies.

It would seem wise on general grounds for the West Indian Colonies, which in the main consist of small scattered units, to unite themselves in commercial relations with Canada, for the growing needs of each are reciprocal in no ordinary degree; and while at the moment there may be gaps and breaks in the interdependence, it seems clear that development taking place under conditions of intimate intercourse will lead to adaptations at present unrealized, and that the growth and development of the Dominion will react most beneficially on these colonies, giving them a degree of coherence and commercial stability not likely to be attained in any other way. It is hoped, therefore, that the many questions arising out of the Report of the Royal Commission will be dealt with on broad lines, and that undue weight may not be given to the less important exigencies of the moment.

The recognition given in the Report to the work of the Imperial Department of Agriculture and the Departments of Agriculture in the West Indies should afford great encouragement to all who are connected with it; at the same time, it should prove stimulating to those engaged in the work of this

Conference, and in similar duties having for their object the advancement of agriculture.

In December 1910 the announcement was made that the Lords Commissioners of His Majesty's Treasury agree in principle to the continued maintenance of the Central Office of the Imperial Department of Agriculture for the West Indies, from Imperial Funds, for a further period of ten years from the first of April 1911. This is tangible evidence of the desire on the part of the Imperial Government to afford a measure of assistance to those West Indian Colonies desiring help, and of a wish to ensure the means of securing a steady and progressive agricultural policy on the part of the several West Indian Governments. The part to be played by the Department and the relationship to be maintained have been clearly explained to the several local Governments, and from the expressions that have reached me I feel assured that this action of the Imperial Government is appreciated by most of the colonies and that, properly availed of, it may exercise a widely beneficial influence.

Agricultural affairs during the past four years have not presented any very striking features. There has been steady progress and a fair degree of prosperity; perhaps the period may be regarded as the most tranquil in a general sense that the colonies represented here have experienced for some time. There has been a steady agricultural awakening, so that agricultural activities are more evident and the outlook covers a wider range than in the past—facts which I think will make themselves obvious during the work of the Conference

A brief survey may, perhaps, be permitted of the principal agricultural industries of the West Indies and British Guiana.

SUGAR.

Sugar occupies the foremost place in the agriculture of this region, and from British Guiana there is exported a far greater amount than from any other colony within the group. Recent exports have been as follows:—

	1905-6,	1906-7,	1907-8,	1908-9,	1909-10,	1910-11,
	tons.	tons.	tons.	tons.	tons.	tons.
British Guiana	116,550	114,951	100,727	115,212	108,535	100,954
Trinidad ...	36,240	45,005	46,207	39,619	45,330	46,247
Barbados ...	41,210	50,630	33,033	31,353	15,570	34,124
Jamaica ...	11,935	13,992	10,623	6,116	9,900	—
Antigua ...	7,805	9,999	13,974	12,516	8,671	—
St. Kitts ...	12,312	15,142	14,132	10,986	11,621	—

The values in the same years were as follows:—

	1905-6,	1906-7,	1907-8,	1908-9,	1909-10	1910-11,
	£.	£.	£.	£.	£.	£.
B. G'na.	1,208,155	1,059,503	1,004,025	1,257,827	1,205,215	—
T'dad.	451,986	430,182	521,082	462,019	565,230	623,949
B'bados.	451,492	351,146	260,410	288,436	152,912	396,003
Jamaica	122,328	118,542	109,775	77,047	118,733	—
Antigua	71,688	71,967	124,424	135,168	82,594	—
St. Kitts	147,153	104,452	117,675	101,900	104,691	—

The criticism has been made that the sugar industry of the West Indies and British Guiana has shown but little expansion during the past seven or eight years, during which conditions have been favourable. It is to be remembered, however, that in the period from about 1897 to 1903 the question was whether this industry would continue to exist, and I may remind my hearers of the doubtful way in which the possibility of such continuance was referred to by the West India Royal Commission of 1897.

Had the conditions continued that were dealt with by that Royal Commission, there is little room for doubt that the sugar industry would have collapsed in more than one district. The measure of progress, therefore, must consist not merely in comparing the output of the two periods, but in observing that the industry still continues, and in ascertaining the financial condition in which the industry stands.

In all the sugar-growing colonies, there is at the moment a spirit of progress largely manifesting itself in the improvement of the means of making sugar. In British Guiana and Trinidad the manufacture of muscovado sugar has long become a thing of the past, while in the last two or three years considerable improvements have been made in the sugar factories of those colonies, involving the investment of no inconsiderable amount of capital.

In Barbados an active movement is in progress, resulting in the substitution of the vacuum pan system of sugar-making for the muscovado process: and although in most instances the new equipments are small, when judged by modern standards, they imply the introduction of triple effects, of multiple crushing and of many changes that make for advancement. A few of the factories, however, are of a fair size, being capable of making crops of some 3,000 or 4,000 tons in a season, and there is a steady tendency in the direction of enlargement. In Barbados, therefore, very considerable sums of money are being invested in improvement, indicating an appreciation of the greater stability of the industry.

In Jamaica there has been marked activity in the improvement of sugar machinery, amounting practically to a revival of sugar-growing in some districts. Several entirely new, well-equipped factories have been erected and it is likely that more will follow. In this Colony great importance attaches to the value of rum, which has an export value greater than that of sugar; in other colonies the rum industry, while important, is subsidiary to that of sugar. The value of the rum exported from Jamaica during the past five years was:—

1905-6,	1906-7,	1907-8,	1908-9,	1909-10,
£.	£.	£.	£.	£.
98,923	134,114	174,955	186,803	234,151

In the smaller islands Antigua and St. Kitts, the activity in the direction of the improvement of sugar machinery has been intense. The successful working of the pioneer factory at Gunthorpes in Antigua has led to its substantial enlargement; it has

now an equipment capable of turning out 70 tons of sugar a day. A still larger factory is on the point of completion in St Kitts; this is to be opened in about a month's time. Its capacity is in the neighbourhood of 90 tons of sugar a day, and it is anticipated that this may be increased as the means of reaching outlying cane-producing areas are acquired. The capital invested in these two undertakings is approximately a quarter of a million sterling, and this fact alone speaks clearly of restored confidence in what, in 1897, was regarded as a moribund industry.

Still further enterprises are under discussion, and it is hoped that when the time for another Conference has arrived there may be a story of continued progress to lay before it.

Scientific work connected with the sugar industry has been fully maintained. I must leave it to the leading workers in this field to present to you the records of what has been done. Messrs. Harrison and Stockdale have carried out much work of the greatest interest, and it is pleasing to note that in their treatment of questions relating to seedling sugar-canes, they have adopted a philosophic attitude, and endeavour to obtain an insight into the fundamental principles underlying the work in the hope of directing investigations along sound lines. I hope that these and many other results will be brought before us by these workers.

The experiments relating to sugar-canes in Barbados have been continued in the manner followed in former years. From one aspect partcularly, the results have a considerable interest and value in that a large number of new seedling canes of promise have been produced and placed in the hands of the planters for introduction into cultivation. An account of the work will be presented by Mr. J. R. Bovell.

Similarly, the work in the Leeward Islands has been carried on in the way followed for some years; in this Colony it has been found necessary to take advantage of new seedling canes raised in other countries, the dry atmosphere of Antigua and St. Kitts making it difficult to obtain fertile cane seed, except in an abnormally wet autumn, though some progress has been made and a few local seedlings are attracting the attention of planters. A considerable amount of attention has been given to cultural methods—an effort partly induced by a desire for progress and partly by pressure from shortage of labour.

The conditions surrounding the sugar industry in the various West Indian Colonies and British Guiana are so diverse that the methods and procedure of one colony are often obscure to the workers in another. This very diversity should prove a source of development; for the interchange of views and experiences, for which this Conference offers unrivalled opportunities, should lead to an expansion of knowledge, and diffusion of new methods over a wide range.

Cacao.

The cacao industry is of importance to Trinidad, Jamaica,

Grenada, St. Lucia and Dominica. The exports from these places during past years have been as follows:—

	1905-6, cwt.	1906-7, cwt.	1907-8, cwt.	1908-9, cwt.	1909-10, cwt.	1910-11, cwt.
Trinidad	432,288	246,169	444,023	438,724	460,492	516,595
Jamaica	31,066	47,564	47,469	49,142	57,454	41,444
Grenada	103,091	73,743	102,483	101,370	108,128	118,667
St. Lucia	16,908	14,100	15,353	12,098	19,554	14,610
Dominica	11,569	11,208	11,463	9,537	10,680	—

The values of these quantities are shown in the following table:—

	1905-6, £.	1906-7, £.	1907-8, £.	1908-9, £.	1909-10, £.	1910-11, £.
Trinidad	1,041,109	802,070	1,786,386	1,152,285	1,131,425	1,230,097
Jamaica	52,813	109,992	151,903	90,914	110,049	—
Grenada	243,790	166,538	361,128	311,519	248,398	259,365
St. Lucia	38,041	41,538	47,292	30,487	—	40,935
Dominica	24,970	34,653	35,440	29,486	23,051	—

The fluctuations are such as are incidental to fruit crops to which, in some senses, cacao belongs. It is open to question whether the output of cacao is increasing as fast as one might expect from the extent to which new plantings are being carried on—a matter that might profitably engage attention.

The circumstances of the cacao industry will afford much material for consideration at the Conference. As the cacao tree is affected in a marked degree by the conditions by which it is surrounded, it presents numberless problems for consideration, connected with climate, soil, cultivation, manuring, blights and pests. These are of great interest to investigators, and of the highest importance to cultivators.

Much interest has centred lately in the cultivation of definite and improved varieties, and their suitability for particular localities and for particular markets. In this connexion the successful introduction of grafted cacao claims attention.

Many papers on these subjects will be laid before us, and opportunities will be afforded for visiting various cacao cultivations, both of a commercial and experimental character, that should prove of great value to the delegates specially interested in this branch of agriculture.

COTTON.

Great interest has centred in the revival of the cotton industry in the West Indies. From insignificant beginnings in 1901, it has grown to one of considerable magnitude, as the following figures show:—

SEA ISLAND COTTON EXPORTED FROM THE WEST INDIES DURING OCTOBER 1, 1910 TO SEPTEMBER 30, 1911.

Colony.	Weight, lb.	Estimated value, £.
Barbados	720,573	42,346
St. Vincent	558,786	44,237
Montserrat	404,733	30,362
Nevis	344,395	24,603
St. Kitts	329,322	24,067
Anguilla	148,595	10,207
Antigua	96,992	6,795
Virgin Islands	50,337	3,180
Trinidad and Tobago ...	6,056	456
Grenada and Carriacou* ...	274,224	10,205
	2,940,033	196,458

As is usually the case with any new industry, the cotton industry in its revival has passed through many vicissitudes. In some colonies its re-introduction has not been attended with the full measure of success that was looked for, but in many places its progress and expansion have exceeded the most sanguine expectations; so that to-day cotton-growing forms the staple industry of St. Vincent, Montserrat, Nevis, Anguilla and the Virgin Islands, and is a prominent feature in the agriculture of Barbados and St. Kitts. Considerable interest in cotton-growing is taken in Tobago, while in Antigua, where it has met with peculiar difficulties, the industry shows signs of reviving. In Carriacou and Grenada, interest in this crop is increasing.

The successful re-introduction of the cotton industry has profoundly improved the industrial conditions of several of the islands, and has greatly lightened the Government's task of administration. Even in those cases where the changes brought about by the industry are of smaller magnitude, the advantages to the community are very great.

The re-introduction of cotton-growing affords a striking instance of the value of associated action extending beyond the confines of any one small colony. It is safe to say that, without the almost simultaneous introduction of cotton-growing into a number of islands possessing most diverse conditions, without the interchange of information, coupled with the study of cotton pests, diseases and difficulties, rendered possible by such an organization as the Imperial Department of Agriculture, and without the readily available help as regards all that concerned markets and their requirements, focussed and rapidly applied by the British Cotton Growing Association, both of which organizations were closely in touch with all that was going on, efforts would have failed in the individual islands from the circumstance of their isolation, and no cotton industry would have come into existence: the pioneers would have been beaten in detail, but were saved by being united. This story contains obvious lessons which need not be enlarged upon here.

* This Colony only shipped 8,643 lb. of Sea Island cotton lint, valued at £566, the balance being Marie Galante.

During the immediate past, the market for Sea Island cotton has been somewhat depressed, but there are grounds for hoping that a revival of trade and some changes in fashions incidental to ladies' dress may give rise to brighter prospects in the near future.

Careful observation leads to the conclusion that there has been material improvement in the quality of the cotton produced in the various islands. That improvement is largely due to careful study of the types of cotton that were introduced in the early stages of the revived industry, and to the selection of useful varieties suitable to the several districts. In this work, which has had very considerable commercial value, the agricultural officers in the Experiment Stations have played an important part, and they have been well supported by the efforts of those cultivating cotton on a commercial scale. As a result of these united efforts, it may be said that the fear that originally beset us, that we might not be able to maintain the quality of the cotton at the high standard demanded by the fine spinners, has been converted into a lively hope that, as time goes on, further improvement may be effected in the quality and in the adaptation of particular varieties to the several districts, with their diverse conditions.

It may be remarked that the cotton industry, in addition to affording new forms of agricultural employment, has given certain communities a new subsidiary industry in the preparation of oil from cotton seed; and the oil factories now in operation in Barbados, St. Kitts and Nevis are the direct outcome of this.

RUBBER.

Interest in rubber has been steadily maintained in the West Indies during recent years, and considerable progress is being made. As far as observations go, the rubber boom of 1909 appears to have exercised but little disturbing influence on the work in the West Indies; this is perhaps due in no small degree to the steadying influence of the local Departments of Agriculture, which, being in close touch with planters and well informed as to local conditions, tended to discourage wild speculations, to the permanent good of the various colonies.

Work in the West Indies has included chiefly the introduction of rubber plants of various kinds and the extension of the areas under cultivation. It may be observed that there is now a tendency to pay more attention to Hevea and less to Castilloa than was formerly the case.

Very considerable efforts have recently been made by the various Departments of Agriculture to assist in the importation of rubber seeds, principally of Hevea; this is shown by the figures for some of the smaller islands, given in the following table:—

	Rubber seeds imported, 1910.
Dominica	98,200
Antigua	2,500
Grenada	75,000
St. Vincent	10,000
St. Lucia	10,000

In Trinidad and British Guiana, this work has been done on a much larger scale.

Much interest has been evoked by the machine invented by Mr. Smith of Tobago for the rapid preparation of rubber from Castilloa latex. It is anticipated that an opportunity will be afforded to members of the Conference for seeing this machine in operation, and for obtaining the latest information concerning it and its application.

It is interesting to note that British Guiana is exporting rubber to the value of some £7,000 a year and that Tobago has begun to make commercial shipments. The values in the latter case have been :—

Year.	Value, £.
1906-7	174
1907-8	603
1908-9	308
1909	1,388

Reference should be made to the export of balata from British Guiana. This is an old industry in this Colony, and is dependent upon the exploitation of the native forests, the work of collecting being carried on under Government regulations intended to prevent destruction or waste of the forests. The importance and growth of the industry may be judged from the following figures relating to the exports :—

Year.	Value, £
1905-6	40,311
1906-7	50,106
1907-8	76,778
1908-9	98,128
1909-10	95,507
1910-11	139,623

The recent International Rubber Exhibition has afforded several West Indian Colonies opportunities both for bringing to public notice the facilities that they offer for rubber cultivation, and for gathering much valuable information to guide the efforts of those concerned in the developments that must take place in West Indian rubber-production. At the Exhibition, British Guiana, Trinidad and Tobago were prominently represented, creating favourable impressions that should materialize in increased activity in rubber-growing. The exhibits from the other West Indian Colonies—Dominica and St. Lucia—were on a smaller scale.

COCOA-NUTS.

The importance of cocoa-nuts in West Indian agriculture is steadily increasing, and it is now felt that the cultivation of the palm may prove one of the most remunerative agricultural industries open to exploitation. Attention may be directed towards the utilization of suitable lands, to be found near the sea in practically every island. The attention of Departments

of Agriculture may well be directed towards this industry, with a view to aiding its extension and to providing means whereby the difficulties which always surround the early stages of an industry may be overcome.

Cocoa-nut production has already assumed considerable magnitude in Jamaica and Trinidad, as the following figures show:—

Year.	Exports, Jamaica,	Exports, Trinidad,	
		Cocoa-nuts,	Copra,
	£.	£.	£
1904-5	17,197	21,832	—
1905-6	28,369	29,228	—
1906-7	44,255	40,500	—
1907-8	57,038	45,233	—
1908-9	44,523	57,284	—
1909	54,941	63,086	—
1910	—	66,651	18,707

In addition to those exported, it must be remembered, cocoa-nuts to an appreciable value are consumed locally; there are also exports of cocoa-nut oil, and cocoa-nut meal and copra.

There are abundant indications that the value of the cocoa-nut industry to these and other West Indian Colonies will rapidly increase in the near future.

Serious diseases of cocoa-nut palms are known to exist; information concerning some of these will be laid before the Conference. It is important that departmental officers should keep themselves well informed concerning these diseases, and that they should be assured that care is taken, in obtaining material for planting, that this comes from uninfected areas.

Rice.

The development of rice-growing in British Guiana affords a most striking instance of the growth of a new industry, and its importance to colonial commerce. This industry may be said to have originated in 1898, on an area of about 6,000 acres, which increased to about 38,000 by 1908. The figures showing the growth of the industry by the values of the exports are as follows; they do not take any account of the more important consumption of home-grown rice within the Colony:—

Year.	£.
1906-7	18,558
1907-8	39,879
1908-9	50,064
1909-10	64,617
1910-11	50,603

It is interesting to note that questions dealing with the improvement of the varieties of rice cultivated in British Guiana now occupy a very considerable portion of the time of the experiment stations, and interesting and valuable results

have been obtained already. It is anticipated that Messrs. Harrison and Stockdale will place before the Conference a summary of these researches, and their bearing upon the future of the rice industry of the Colony.

The cultivation of rice is now extending into the Colony of Trinidad, and it has assumed dimensions of somewhat considerable magnitude. It is stated that there are now some 11,000 acres under cultivation in this crop, the produce of which is consumed locally.

It would seem that the development of the rice industry will, at any rate for the present, be limited to those colonies having large areas of low-lying land, together with an East Indian population, but that in these places this industry may be one of very great commercial importance.

Arrowroot and Starches.

It is interesting to place on record that a very determined effort is being made to put the arrowroot industry of St. Vincent on a more satisfactory footing. To this end, legislative action has been taken to raise an arrowroot cess to be employed in exploiting new markets and in extending the consumption of arrowroot by advertisement and other means, and in order to assist in the matter, an Arrowroot Growers' and Exporters' Association has been formed in the island. Recent enquiries from Canada lead to the hope that cassava meal and starch may find an entry into the Dominion as raw material to be used in the manufacture of syrups and laundry starches. The production of arrowroot in St. Vincent during the past six years has been :—

Year.	Quantity, lb.	Value, £.
1905-6	4,356,169	20,523
1906-7	4,643,124	24,351
1907-8	4,501,637	25,556
1908-9	5,611,379	27,713
1909-10	5,594,498	31,791
1910-11	5,302,725	30,089

Fruit Industry.

An export trade in fruit has reached the highest degree of importance in Jamaica, where the cultivation and shipment of bananas constitute the principal agricultural industry of the Colony. Active efforts are in progress in Trinidad in the direction of the establishment of a trade in bananas, and there is reason to hope that this may rapidly grow. Both these colonies are favourably situated as regards shipping facilities—a factor of prime importance in connexion with any effort to establish a fruit trade.

Oranges and grape fruit are exported from Jamaica on a very considerable scale, as is shown by the figures given below.

Attention may be drawn to the steadily increasing trade in fresh limes that is growing up between some of the smaller West Indian Islands and New York, in connexion with which special reference may be made to the development of this trade from the island of Dominica.

The following figures, showing the value of fruit exported from certain colonies, indicate the salient points of the trade in fruit:—

JAMAICA.

Year.	Bananas, £.	Oranges, £.	Grape fruit, £.
1904-5	514,191	62,095	6,347
1905-6	842,689	90,460	9,109
1906-7	880,531	70,951	12,613
1907-8	1,038,721	77,105	19,591
1908-9	1,044,820	38,474	13,366

TRINIDAD.

Year.	Fruit. £.
1904-5 ...	803
1905-6 ...	4,259
1906-7 ...	4,682
1907-8 ...	11,076
1908-9 ...	16,081
1909 ...	20,836
1910 ...	19,956

DOMINICA.

Year.	Fresh limes, £.	Pickled limes, £.	Oranges, £.
1904	2,856	865	615
1905	4,748	642	554
1906	5,529	1,615	482
1907	6,409	579	666
1908	9,154	729	582
1909	9,009	754	1,087

The question of the increase of fruit-growing and exporting along new lines appears to be intimately bound up with that of the development of improved trade relations and increased shipping facilities between the West Indies and Canada. It is in this direction that the opportunity appears to lie for the creation of a fruit trade in many of the smaller islands. The ultimate issue of this question is therefore awaited with interest.

LIVE STOCK.

While the amount of live stock, existing in the various West Indian Colonies has, in the aggregate, a very considerable commercial value, it would seem that there is some want of definiteness of purpose in the manner in which matters relating to the raising of stock are dealt with, both by private individuals and Departments of Agriculture. The question is one which presents peculiar difficulties, and many attempts

have been made to improve matters in practically every colony, but not always with the degree of success that was expected. In Jamaica, only, does any very considerable attention appear to be given to the raising of live stock; in most other colonies the matter seems to be on a less business-like footing. In order to securé developments in these directions, there have been established Government Farms in Jamaica, British Guiana and Trinidad, and smaller efforts have been made in connexion with the experiment stations in some of the smaller colonies. As far as the work of the Imperial Department of Agriculture is concerned, an attempt has been made to encourage the importation of improved animals by the offer of bonuses having a value of some 25 or 30 per cent. of the cost of the animal imported. This procedure was adopted under the impression that probably animals owned and imported by individuals would be more valued and better appreciated than those attached to public institutions. It may be well to point out that in several of the colonies some serious attempts have been recently made to undertake the raising of mules according to improved methods. Further development of these efforts is a matter deserving the careful consideration and all possible assistance on the part of the Governments concerned.

Distribution of Plants.

A great deal of activity has been manifested in some colonies in the distribution of plants; this has largely consisted in the sending out of new or improved varieties of plants relating to crops already grown, though efforts are not wanting in the direction of the introduction of new plants and the attempts to assist new industries. In connexion with the latter, the importations and distribution of rubber seed may be referred to; in regard to the former the distribution of varieties of canes, of cotton and rice, of sweet potatoes and many other plants. Some idea may be gathered of the activity which has prevailed in this direction by reference to the *West Indian Bulletin*, Vols. X, pp. 146-52; XI, p. 426

Plant Protection.

In recent years, greatly increased attention has been given to the necessity of imposing measures for limiting the spread of pests and diseases inimical to plants, and every British West Indian Colony is now provided with legislation having this object. When legislation of the kind now in force was first advocated, the proposals were often met with opposition or indifference, and the fear was expressed that the restrictions would be more irksome than beneficial. I think it is safe to say that a different feeling now prevails, and that plant protection laws are recognized as a necessity.

The losses due to plant diseases are enormous, and sufficient in some cases to threaten the stability of some industries; at the same time it is recognized that some of the diseases are confined to particular areas, and to fight these troubles where they exist, and to prevent their spread to other districts, form a very important part of the duty of agricultural officers.

This phase of work, for its proper accomplishment, necessitates a very complete system of interchange of information with regard to the pests that are present in various localities and the steps that are taken to control them, and I express the opinion that there is room for considerable improvement in this particular. A useful summary of the legislation on this subject in the various colonies, and of the methods adopted in this connexion appeared in the *West Indian Bulletin*, Vol. X, pp. 197-234, and pp. 349-72.

An attempt to place on record the principal plant pests and diseases occurring in the smaller West Indian Islands has been made by Messrs. Ballou and South, who have given already, in the *West Indian Bulletin*, Vol. XI., pp. 73 to 106, the results of the information for 1909-10 collected from the agricultural officers in the colonies concerned, and will lay before this Conference the results of similar enquiries carried on up to the present time. Special attention may be drawn to this line of work, for it appears worthy of further extension, and might with advantage, be made to include the whole of the West Indies.

PRIZE-HOLDINGS SCHEMES.

Attention may be directed to a very useful line of work which has been followed in several colonies where special efforts are being made to improve the condition of the peasantry; I refer to prize-holdings competitions. These consist in the offer of prizes for competition amongst the peasants in stated areas; they are awarded for good work done on the competitors' small holdings. These competitions are very useful, for they not only enable those who participate to appreciate the results of good work and lead them thus to compare notes with their neighbours, but they also offer a field in which the agricultural instructors can give instruction to persons ready to listen and avail themselves of their advice. The good work done through these agencies is calculated to be wide-spread and lasting.

In the lesser Antilles, such competitions are held in Grenada, Carriacou, St. Lucia and Dominica. They receive much attention in Jamaica and Trinidad.

PEASANT INDUSTRIES. LAND SETTLEMENT SCHEMES.

Progress has been made in fostering peasant industries, so that at the present moment the value of the effort by small holders is, in the aggregate, very considerable. Under various industrial systems, peasants now supply large quantities of canes to factories; for instance, in Trinidad, the quantity of canes supplied by farmers to factories in 1911 was 165,700 tons, having a value of $357,560 (£74,496). In Antigua the cultivation by peasants of canes for sale to the factories is followed on a considerable scale. In addition, peasant-grown canes are dealt with in small sugar works, and chiefly under a share system, in most of the islands.

The raising of peasant-grown cotton forms an industry of some importance to several small communities. In Montserrat, it is estimated that during the season 1910-11 there were

approximately 800 acres of cotton, grown by peasants, out of a total area of 2,050 acres under cotton in the island. In Nevis, the statement is made that, of the 1,300 acres under cotton cultivation for the crop of 1910-11, some 540 acres belonged to peasants; while it is further estimated that out of the 2,000 acres planted in cotton in this island for the crop of 1911-12, fully one-half, or over 1,000 acres, is the property of peasant growers.

The growing of cacao by peasants is an important industrial feature in Dominica, and in Grenada and St. Lucia.

In connexion with peasant industries, reference may be made to the cultivation of limes. In Dominica a fairly large supply of limes comes from peasant sources, while in the Virgin Islands the Department of Agriculture is endeavouring to establish a peasant lime industry on somewhat similar lines to its successful peasant cotton industry.

In the Presidency of St. Vincent, there has long been in operation an effort to establish peasant holdings. In 1897, this effort resulted in the formation of a very definite Land Settlement Scheme, which arose under the urgency of stress from the disastrous hurricane of September 1898, a further impetus being given by the volcanic eruptions of 1902-3. Several estates, having a combined area of 5,000 acres, were acquired by the Government for this purpose. A full account of the working of this scheme from 1898 to 1910-11 has been prepared by Mr. M. Tatham, Private Secretary to the Hon. Gideon Murray, the Administrator, and published as Colonial Reports—Miscellaneous, No. 77. From this it may be gathered that the work has been productive of a very great amount of good, and is resulting, as the report states, in the production of a class of peasant proprietors who have either become, or are becoming, absolute owners of the land; they have the knowledge that every particle of labour which they put into that land will be for their own benefit. During the period in which they pay, and even afterwards, if they so desire, they are carefully instructed in agriculture and receive free information as to the best methods of obtaining the maximum yield which the nature of each particular allotment will allow.

A detailed account of the agricultural aspect of the St. Vincent Land Settlement Scheme, by Mr. W. N. Sands, Agricultural Superintendent, is given in the *West Indian Bulletin*, Vol. XI, p. 194. Under the scheme the peasants acquire full possession of their holdings by a system of annual payments completed in sixteen years.

A subsequent extension of the Land Settlement Scheme has been the acquirement, by the Government of St. Vincent, in 1910, of Union Island, and its appropriation for peasant holdings. The lands thus rendered available are sold to carefully selected peasant proprietors, on a twelve-year instalment plan. The progress that has been made in the short time that the scheme has been in operation gives every promise of success.

Another important effort in the same direction is the Land settlement Scheme of Carriacou. This was begun in 1901 and

an interesting account of the early stages of progress, by the Hon. Edward Drayton, C.M.G., is published in Colonial Reports —Miscellaneous, No. 24, under date September 7, 1903. In the period that has elapsed since that report was written very substantial progress has been made, so that it is recorded now that there may be observed the gradual creation of a body of contented landowners, and the rapid consequent growth of prosperity, in an island which some years ago presented a picture of misery and desolation.

Encouraged by the success of these ventures, the Government of Grenada has recently undertaken an important Land Settlement Scheme in that island. Estates have been purchased in two districts, and laid out for occupation by peasants under a system of purchase by easy payments spread over a period of twelve years. The land is being rapidly occupied, and there is good ground for supposing that this scheme will be as successful as those just mentioned. A small set of works for the manufacture of muscovado sugar by the peasants is in course of erection on one of the blocks of land under settlement, and a cotton ginnery has been built within easy reach. As in the Land Settlement Schemes of St. Vincent and Carriacou, care is taken in Grenada that the work of the peasants shall be carefully supervised by competent agricultural officers, who watch closely the operations in progress, and advise concerning the crops to be cultivated and the manner in which they should be dealt with.

From all this, it may be gathered that there are now at work throughout the West Indies many agencies for advancing the agricultural interests of the peasant.

While a summary of the position and progress of agricultural affairs during a recent brief period is instructive, I think we may learn more concerning the changes that have taken place and the progress that has been made, and may appreciate them better, if we look farther back and make comparisons with more distant periods. Upon making such a retrospect, nothing strikes me more forcibly than the different position in public esteem now occupied by what I may term the scientific side of agriculture.

If we compare the present position of affairs with that existing some fifteen years ago, striking changes will be seen. In the years preceding this period two lines of effort are apparent, one tending in the direction of the establishment of botanic gardens, having largely for its object the introduction of new plants for the improvement of existing industries and the establishment of fresh ones. The important Botanic Gardens of Jamaica, Trinidad and British Guiana, and the effort to establish similar, if more modestly equipped, gardens in the smaller colonies arose under this influence; amongst these, that formed in Dominica has been conspicuously successful in meeting the immediate needs of that Presidency

The other line of effort manifested itself in the establishment of chemical laboratories. In the early days, while agricultural matters claimed the attention of these laboratories, they only exercised a partial effect; they were also charged

with other very important duties such as chemico-legal work and analysis for revenue and customs purposes, the agricultural aspect being largely confined to the performance of analyses, either in response to the demands of planters, or in some cases, by way of investigation of agricultural problems. In these early stages there was little definite inter-association between the botanical and the chemical workers.

Changes took place gradually, and the association became closer, in a large measure because of the interest of the officers in the problems before them rather than through direction on the part of the Governments with which they were connected. Out of this grew the tendency which marks the next stage of progress.

In Europe and America, about this time, there was a considerable movement in the direction of agricultural experiments in which chemists, botanists and farmers worked in associations, and the efforts in the various West Indian Colonies began to assume a similar character; so that in most places the various scientific officers of the Government, whose duties touched agricultural matters, worked together energetically to foster developments along these lines. These efforts appealed to practical planters, and in turn reacted upon the Governments concerned.

This may be taken broadly to be the position of affairs when the West India Royal Commission visited these colonies in 1897. This Commission recognized the existence of the powerful agencies thus working toward the amelioration of West Indian agriculture, and made the suggestion to assist and to afford stability to these agencies by granting monetary assistance from Imperial sources and by linking up and supporting the work carried on in these scattered colonies, by means of the Imperial Department of Agriculture.

This Imperial recognition and encouragement of scientific effort in agriculture had most important results. In the first place, the various West Indian Governments and communities realized that scientific effort in agriculture was regarded seriously and was accorded high Imperial recognition; and in consequence, local official support and recognition were strengthened, the development of agricultural investigations obtained the serious attention of those entrusted with colonial administration, and scientific workers were encouraged by the assurances of support thus accorded to them. In addition to this moral support came the tangible and welcome monetary aid from Imperial funds, to set matters on a sound footing and to maintain them, as far as the smaller colonies were concerned, without anxiety as to ways and means, for a period of at least ten years, subsequently extended.

The result was a great quickening of scientific agricultural effort throughout the West Indies—an effort which exhibited itself in many phases: the introduction of new industries, experiments bearing upon the old, a more throrough study of plant pests and diseases than had ever been undertaken before,

greatly increased attention to agricultural education in primary and secondary schools and even in wider ranges, together with a very great addition to the publication of agricultural reports and general literature, and a diffusion of agricultural knowledge such as had never been experienced in the West Indies.

The Imperial Department of Agriculture, being at this time established, was the centre of much of this activity, and in the smaller colonies largely directed and controlled it. The larger colonies, however, shared in the general stimulation and greatly benefited by the extended official recognition given to agricultural research and, as the outcome, we find the Departments of Agriculture of these colonies assuming a greater degree of importance in the administration of affairs than they have ever taken before.

While the tendency of the Imperial Department of Agriculture was to unite the various workers in the movement just sketched, the growth of local organizations has led to a desire to emphasize the importance and independence of outside aid; this is a natural outcome of the feeling of strength and security engendered by the fostering period recently passed through. While this feeling is in the main good and useful, it has its dangers, for the spirit of independence, so created, tends to develop a desire for isolation, in order that it may be demonstrated how strong and independent is each centre, or even each worker. Unless there is some counteracting influence at work, there will be a loss of efficiency in the future from this cause. The history of the past shows that it is easy to secure isolation in West Indian affairs, but very difficult to ensure co-operation.

I am led, however, to think of a still further phase of development as the outcome of this growth in agricultural matters. As the various agricultural industries grow and gain strength, they in turn tend to become self-dependent. The tendency is for them to pass into the hands of large corporations, so that it becomes possible to produce a high degree of specialization. In this way the knowledge of the details of a particular industry tends to pass beyond the limits of knowledge of a local Department of Agriculture, and the Department has to surrender certain lines of enquiry and progress as being beyond its scope.

It would not be difficult to draw illustrations, to support my view, from the sugar industry, from the cotton industry, from the cacao industry, or indeed from any industry which has grown to sufficiently large dimensions in any one place. One may look forward to development on these lines, for instance, in the rubber industry; so long as the work is of a pioneer character, the aid of the officers of the Department of Agriculture will be sought, but soon after the industry has extended greatly, the workers in it will have more knowledge concerning certain phases of it than the department officers can possibly possess, and the agricultural department will in these particulars rather follow than lead.

All this has a bearing on the work which departments of agriculture will be called upon to do. In the technical details of manufacture, or of cultivation, large corporations will soon acquire and apply knowledge for themselves; they are less likely, however, to gain information directly concerning new plant pests and diseases, hence there will always remain to the Department the duties of studying the life-histories of these pests, both fungus and insect in nature, and of devising means for their control. Beyond this, too, there lie many abstract problems in the realm of new knowledge which will appeal to the departmental worker before they make their call to the practical man. It is possible that from these problems, the scientific worker will evolve new methods of working, which he may hand on to the commercial worker, and see them absorbed into the common practice of daily life and pass beyond his guidance or control. Some inferences as to my meaning may be drawn from the work now being pursued with great activity along the line of directing or controlling the activities of the organisms in the soil, from which it is conceivable that new agricultural methods may arise in laboratories and experiment stations, to pass later into routine agricultural practice.

Perhaps I may be permitted to claim that these are not mere idle speculations; I think they have their applications and that those responsible for the creation and administration of agricultural departments may draw a lesson from them. They imply that much of the work of such departments must be of a pioneering character; that as soon as results are achieved, they are accepted and developed by the practical man, whose commercial application of them, and possible extension and development of them, throw the achievements of the scientific worker into the shade.

From such causes the feeling arises in the minds of the less thoughtful that scientific workers are not as usefully employed as are so-called practical men, and from this comes the oft-repeated cry as to what is the use of this or that work—a cry often too readily attended to by the embarrassed administrator desirious of economizing—a cry harassing and deadening to the enthusiastic worker.

In following this line of thought, it will be seen that there can be no finality in the work or in the organization of Departments of Agriculture: growth implies change and new adaptations, and it is well to recognize that these changes are the result of natural processes of healthy development, though in their local manifestations they may, at times, appear to be due to the caprice of individuals. The duty of wisely directing such changes in colonies where the Government is largely concerned with the administration of these affairs lies upon the Executive, which should possess a wide knowledge of the work being done, of the progress being made, and of the real needs of the community; for while the views of departmental officers are very valuable, it must not be forgotton that there is a danger of their being wanting in breadth, on account of the limitations of their work, so that greater responsibility lies

upon the Executive, in matters of change, than is perhaps commonly recognized.

The time has now arrived (and the constitution of this gathering, bears ample witness to the recognition of the fact) that the immediate assistance and encouragement of agricultural affairs in their widest sense have become prominent features in the Government administration of the colonies. The stages of evolution that have been passed through have rendered necessary the formation of Departments of Agriculture, even for the smallest colonies: they are now rendering necessary the formation of agricultural policies on the part of the respective Governments, so that the activities of these departments may be wisely directed and the needs of agriculturists may be best served. We have reached the period when the study of agricultural needs and difficulties, and the encouragement of efforts to open new lines of development, must be regarded as constituting an object of care on the part of colonial Governments that is as legitimate for their attention as the concerns of education, health and public order.

This introduces what may constitute a difficulty, in that commercial interests are brought dangerously near administrative concerns, and some regard the position with a little apprehension. Much of the danger is, I think, removed by the natural course of progressive changes to which I have made allusion already; whereby, as industries progress and expand, they pass beyond the need of care and direction of agricultural officers, as far as their main features are concerned, leaving the special problems for consideration.

I have referred to the natural tendency towards severance and isolation which exists. I would add that such gatherings as this Conference are calculated to do much to correct the danger so arising; for in these meetings we have a remarkable association of officers responsible for administrative work, of scientific workers ranging from those engaged in laboratory pursuits to those whose duties lie largely in the field, of educationists anxious to give more and more weight in their teaching to matters having an agricultural bearing, and finally of actual planters and merchants whose daily duties should, and in many cases do, embody the ideas and suggestions emanating from the scientific advisers, and who in their turn stimulate activity by making known the real daily needs of each industry or enterprise.

What is more, all these representatives of various phases of agricultural interest are drawn from widely separated colonies possessing most diverse conditions. Interchange of views between the members of such an assemblage must be (and previous experience amply proves that it is) of very great service indeed, and its results are manifest to the great advantage of the colonies from which the delegates come, in increased effort, enlarged views, the introduction of new ideas, not only on the part of the delegates themselves but of the communities which they represent, for on their return revived and stimulated interest is communicated to those amongst whom they follow their daily avocations.

VOTES OF THANKS.

His Honour E. J. CAMERON (Administrator of St. Lucia): Your Excellency, Your Grace, My Lords, Your Honours, Ladies and Gentlemen: It is my special privilege to ask you to join with me in according to His Excellency the Governor a most hearty vote of thanks for his kindness in opening the Conference for us to-day. His Excellency's presence is an indication, as the President has mentioned in his address, of the serious attention which is being paid in all quarters, especially by those who are responsible, in the direction of improvement in the matter of agriculture, and I think you will feel that His Excellency's presence here means that this Conference is to be a really serious matter in which questions affecting agriculture are to be discussed and all the different features which affect it considered, and views exchanged in regard to it with great resultant good to the different communities from which we all come. The sincerity and cordiality of His Excellency's welcome, on behalf of the large and important Colony of Trinidad, will, I am sure, appeal to all of us very much indeed, as well as the extreme care and hospitality which have been manifested by those who have been preparing and making arrangements for our reception. I am sure we are all very grateful to His Excellency for the interest which he has personally taken in this matter. (Applause.)

I have also to ask you, at the same time, to accord a similar hearty vote of thanks to Dr. Watts for the very interesting, able and thoughtful address with which he has opened the actual proceedings of our Conference. (Cheers.) He has sketched throughout all the varying features and agricultural interests, in one or other of which the majority of us are concerned. I, though on the administrative side, am interested in the subject all round, inasmuch as the upraising of agriculture and the uplifting of those agricultural interests in my own island grease the wheels of administration very much. I am here as a learner, and I hope to be able to go back with revived energy to endeavour, as far as my small powers are concerned, to push this matter of agriculture in the land in which I happen to be at the present time. I am glad to notice in the address that reference is made to the former President of these Conferences; with the terms of this I heartily concur, and I think you will all agree that the West Indies owe very much indeed to him. (Cheers.) I speak with a certain amount of fervour because I have worked closely with Sir Daniel Morris, as I have done with Dr. Watts. I remember Sir Daniel Morris particularly when I was in that somewhat distressful land, St. Vincent, where the cotton industry started with such adverse conditions and has since made such astonishing and gratifying progress. We are all grateful to Sir Daniel for his continual interest in the West Indies and for the message which he has sent. I do not intend to keep you longer; I ask you to join with me in according a hearty vote of thanks to His Excellency and to Dr. Watts. (Applause.)

Professor P. CARMODY (Trinidad): I am asked to second this vote of thanks which has just been proposed in such

eloquent terms. It is not necessary for me to say anything more, except to give some information upon a point which perhaps the visitors do not know. It is not surprising to find His Excellency devoting his time to opening this Agricultural Conference to-day, for there is not a corner of Trinidad in which there was anything done in agriculture, at which His Excellency has not quite readily and willingly presided. (Cheers.)

Sir G. RUTHVEN LE HUNTE: I have to thank His Honour the Administrator of St. Lucia, and the Director of Agriculture for their kind vote of thanks. I have pleasure in accepting it not only for myself, but for the three special bodies of which I at this moment happen to be President, and which have all taken very great interest in the preparations for this Conference. I refer to the Government Department of Agriculture, the Board of Agriculture and the Agricultural Society. They have all given the greatest assistance. In accepting your kind vote of thanks I have also accepted it on behalf of other members of the community—the Legislative Council, the members of the commercial community and others who have joined together in trying to make what I am sure, with their help, will be a great success and a feather in the cap of Trinidad. I had almost forgotten to include the Royal Mail Steam Packet Company and the Permanent Exhibition Committee, who have been most kind in helping us in every possible way. (Cheers.)

A paper was then read by Professor P. Carmody, F.I.C., F.C.S. Preparatory to dealing with the paper, Professor Carmody said:—

It is not my intention to read to you a heavy paper this afternoon, but my object is particularly for the purpose of mentioning matters in connexion with agriculture in this Colony which will probably interest visitors during the excursions that will be made in connexion with the Conference. There are many points and many directions in which this Colony is promoting agriculture which are somewhat different from those in the other colonies, and this paper will bring before you the salient points in connexion with this difference. Your interest will follow in certain directions according, of course, to your particular interests, and it will be easy for you to arrange, if arrangments are not completed already, to make special visits by means of excursions to any one particular industry in which you are interested. For my own part I will do my best to assist anyone who wishes to make a trip to different parts of the country.

Professor CARMODY then read the following paper on Agricultural Progress in Trinidad and Tobago:—

MATTERS OF GENERAL INTEREST.

There has been considerable progress in Agriculture in recent years, in the Colony of Trinidad and Tobago, and the object of this paper is to place on record the principal directions in which progress has been made or attempted, and to interest

members of the Conference in the experiments that can be seen by them during their visit.

The new Department of Agriculture started in 1908, and in it are now included :—

(1)	The Government Laboratory
(2)	St. Clair Experiment Station Botanic Gardens, Trinidad " " Tobago
(3)	Stock Farm, Trinidad " " Tobago
(4)	St. Augustine Estate
(5)	River Estate

The annual vote for the work of the Department of Agriculture exceeds £14,000.

The Board of Agriculture was formed at the same time, and has control of funds amounting to about £3,600 per annum. This sum is obtained by an export tax on cacao, sugar and cocoa-nuts, as is shown in another paper to be read at this Conference.

The Agricultural Society, with an annual Government Grant of £600, arranges for local shows, and discusses important questions connected with agriculture at its monthly meetings.

The Permanent Exhibition Committee arranges for Exhibitions held outside the Colony, the cost being defrayed from an annual Government Grant of £200.

These four bodies are now actively engaged in promoting the agricultural interests of the Colony, and they control a total expenditure of over £18,000.

I will now compare the present position of the principal agricultural products exported with that of the exports for the years 1895, 1900, and of 1903-4, when the Agricultural Conference was previously held here.

EXPORTS OF CACAO.

Year.	Quantity, lb.	Value, £.
1895	29,458,688	620,634
1900	30,383,808	852,568
1903-4	36,154,048	897,033
1910	57,858,640	1,230,097

EXPORTS OF SUGAR AND MOLASSES.

Year.	Sugar, quantity, tons.	Sugar, value, £.	Molasses, quantity, gals.	Molasses, value, £.
1895	54,623	596,415	1,498,215	42,551
1900	40,619	550,009	777,279	26,165
1903-4	40,384	435,931	328,352	7,001
1910	46,248	723,949	743,679	10,433

The local consumption of sugar is about 8,000 tons.

EXPORTS OF RUM AND BITTERS.

Year.	Rum, quantity, gals.	Rum, value, £.	Bitters, quantity, gals.	Bitters, value, £.
1895	178.167	10,455	40,129	40,129
1900	33,548*	4,010	37,138	37,138
1903-4	127,068	6,355	28.130	28.130
1910	191,641	9,587	33,521	33,521

*An abnormally low export.

The local consumption of rum is about 330,000 gallons.

EXPORTS OF COCOA-NUTS AND COCOA-NUT OIL.

Year.	Cocoa-nuts, quantity, (number).	Cocoa-nuts, value, £.	Cocoa-nut oil, quantity, gals.	Cocoa-nut oil, value, £.
1890	10,211,320	24,967	...	...
1900	9,565,818	15,565	12,581	1,261
1903-4	9,985,207	20,041	36.715	4.526
1910	18,872.962	66,651	2,086	432

EXPORTS OF COPRA AND COCOA-NUT MEAL.

Year.	Copra, quantity, lb.	Copra, value, £.	Cocoa-nut meal, value, £.
1895	...	...	...
1900	...	3,378	53
1903-4	2,361,803	10,721	285
1910	2 046,621	18,707	...

EXPORTS OF FRUIT.

Year.	Value, £.
1895	126
1900	517
1903-4	1,280
1910	19,952

EXPORTS OF COTTON.

Year.	Quantity, lb.	Value, £.
1895	...	..
1900	...	...
1903-4	...	...
1910	11,315	626

EXPORTS OF TIMBER.

Year.	Value, £.
1895	..
1900	12,802
1903-4	4,472
1910	19,111

EXPORTS OF RUBBER.

Year.	Quantity, lb.	Value, £.
1895	...	...
1900	...	...
1903-4	...	..
1910	7,376	1,395

RICE PRODUCTION. (No Exports.)

Year.	Quantity, lb.
1910	10,488,320

(Production consumed locally.)

In a pamphlet prepared by the Organizing and Reception Committee for the Conference, it is shown that the total value of the principal agricultural products exported has, since the last Conference was held here, increased fron £1,417,000 (in 1903-4) to £2,140,000 (in 1910).

The areas under the principal crops are:—

	Acres.
Cacao	290,000
Sugar	62,600
Cocoa-nuts	18,700
Rice	10,400
Coffee	4,120

The acreage under rubber cannot be given, owing to the mixed cultivation system under which it has previously been grown.

The cultivation of cacao, cocoa-nuts and rubber is extending as fast as the labour-supply will allow.

Field Studies and Experiments.

Experiments had been carried on by the Botanical Department for several years previous to the date of the formation of the Department of Agriculture. It was felt that these were conducted on too small a scale to meet the present requirements of the Colony, and in consequence, a series of fresh experiments has been started and is carried out by Officers of the Department and of the Board. Experiments connected with fungus and insect pests are under the control of the Board; the others are under the control of the Department, the cost being in some cases borne by the Board and in others by the Department.

CACAO.

The field work connected with cacao includes manurial experiments at River Estate and at other estates in different parts of the island. This enables a rapid study to be made of the manurial requirements of different soils. There are about 80 acres under manurial experiments.

SHADE EXPERIMENTS. The long-discussed question of shade is now being tested at River Estate, on trees of different ages. Full shade, partial shade and no shade are under trial. At San Carlos, Mr. C. C. Stollmeyer is giving no shade an extensive trial; and at Santa Cruz, Mr. A. V. Stollmeyer has a combination of no shade and manurial experiments.

CHUPONS (suckers). This is another much-discussed branch of cacao cultivation, and the experiments are detailed in another paper to be read at this Conference.

CHANGING OF LEAF. This is kept under observation at River Estate.

YIELD OF INDIVIDUAL TREES. This very important matter is now receiving careful attention, and very useful results are expected therefrom.

SEED SELECTION. Seeds selected from the best bearing trees are now obtainable at River estate.

GRAFTED CACAO. A beginning has been made in grafting cacao on the estates.

CANKER. Canker has been studied by the Mycologist to the Board of Agriculture. The late Mr. Carruthers stated that canker here was almost negligible in comparison with that in Ceylon. The spraying experiments carried out by the Mycologist on various estates will be described in a paper that he will submit to the Conference.

INSECT PESTS. The Entomologists to the Board have given attention to the borer beetle, leaf-eating insects, thrips, etc., and much useful information on these pests has been disseminated among planters.

FIELD INSTRUCTION. The Board selected two practical planters to instruct small proprietors in improved methods of cultivating their cacao estates. They have shown small proprietors how to recognize and remedy canker and other diseases. This work has proved very successful in the hands of the two inspectors appointed.

PRIZES FOR IMPROVED CULTIVATION. Arising out of the above, the Board allocated a sum of £200 for prizes to owners or contractors holding not more than 16 acres. In the two districts selected for the first year's competition, there were 340 competitors, and the prizes have been recently awarded. This scheme has proved a great success, and is to be continued this year in two other Wards of the Colony.

SOIL ANALYSIS. In connexion with the manurial experiments, attention is paid to the analysis of soils; and the natural yield of ten plots, each conta—ning 540 trees, is being ascertained

for a period of three years as a basis for future experiments on these plots.

SUGAR.

The field work in progress in connexion with sugar is as follows.

THE FROGHOPPER. The Officers of the Board have given special attention to the study of the froghopper. The planters also secured the services of Dr. Gough for the same purpose. Much work has been done, but the froghopper is still a serious cause of trouble in some parts of some sugar estates.

MANURIAL EXPERIMENTS. Forty-six acres of canes are under trial, with various manures, as is described in Mr. de Verteuil's paper.

SELECTION OF IMPROVED VARIETIES. At the St. Augustine Experiment Station, several varieties of seedling canes, and some imported canes, are grown. Cuttings for planting from the best kinds will be distributed to the estates.

PAPER FROM MEGASS. Since the last Agricultural Conference was held in Trinidad, experiments have been made in the manufacture of paper. A paper mill was subsequently erected, and a brown paper of good commercial quality, made there, sells readily in the local market. As arrangements are now being made to use local oil as a fuel in the sugar factories, the question of the utilization of megass will again come to the front. The mill is not at work, at present.

COCOA-NUTS.

The Mycologist and Entomologist of the Board have been actively engaged in the work of combating diseases on cocoa-nut estates. Trees injured by bud rot have been cut down and buried.

The cultivation of cocoa-nuts is rapidly extending, especially in Tobago.

FRUITS.

BANANAS. These form the bulk of the exported fruit. The cultivation has been hampered in various ways: but notwithstanding this, the value of the exports has risen to about £20,000. Efforts are being made to increase the exports, and recently, when a subsidy was granted to the Royal Mail Steam Packet Company, the requirements of the Colony for the development of the banana industry were carefully considered.

Local experience has shown that, for cultivation on a large scale, the Canary banana possesses many advantages over the Gros Michel, which was first tried on account of its profitable cultivation in Jamaica and elsewhere. The Government has for several years made field experiments on a fairly large scale, at St. Augustine estate, and the results obtained are sufficiently encouraging to justify the Department in recommending the extension of the banana industry on the lines now adopted by the Manager of St. Augustine estate

The yield of bananas from an acre of land is much heavier than that from other crops, and it is not surprising that after a short period of years the yield diminishes considerably owing to rapid exhaustion of the available plant food in the soil. This diminution is sooner or later accompanied by what appears to be a specific disease; but there are grounds for believing that the real causes of the disease are soil exhaustion and the difficulty in finding a suitable rotation crop. This kind of disease appeared at St. Augustine estate, and for a time threatened the extinction of the banana cultivation. The remedial measures that have been tried with a fair degree of success are removal and burial of diseased plants, application of lime to the soil and rotation of crops.

Manurial experiments with bananas are an important feature of the cultivation. It has been proved conclusively that heavy dressings of pen manure (40 tons per acre) are very beneficial and remunerative. Rough temporary pens are erected on the banana fields in order to reduce the cost of the manure and, as the supply of pen manure is usually small in comparison with the area under cultivation, experiments with artificial manures, with and without a light dressing of pen manure, are under trial.

ORANGES. Trinidad oranges are of excellent quality, but owing to the appearance of the skin, they do not sell readily in foreign markets. In course of time the public will no doubt be educated to disregard the appearance of the skin (which is not edible), and to appreciate the delicately flavoured juicy interior; but in the meantime this branch of the fruit industry needs the fostering care of the Government.

GRAFTED MANGOES. A serious attempt has been made to extend the cultivation of this very delicious fruit, and although there has been an unexpected delay, our efforts in this direction will be renewed.

AVOCADO PEARS. This fruit will in the future be an important item in tropical exports. It requires for transport a lower temperature than bananas. I have recently seen avocado pears in London, marketed at 15c. each, which residents in the tropics would not eat.

LIMES. The West Indian lime is making steady progress in foreign markets.

Growers of fruit must now more than ever realize that it is absolutely impossible to secure a place in a new market unless the very best fruit, in the very best condition, is sent there.

RUBBER. Castilloa trees have been tapped during the last seven years, and the rubber exported. The methods of preparing and tapping the rubber on the estates have been carefully studied, and efforts have been and are being made, to improve on these methods, with encouraging results. A paper to be read at this Conference by Mr. A. E. Collens gives details of the work done.

A planter in Tobago has patented a centrifugal machine which separates dry rubber in sheet form, in ten minutes.

Hevea trees have recently been tried as a separate cultivation, and the reports on their growth are very favourable.

Experience has shown that mixed cultivations of rubber and cacao have not been a success.

The difficulties in obtaining plants from imported Hevea seeds have been very great, but the Colony will soon be in a position to supply seeds from trees growing here.

RICE.

There are about 10,000 acres under rice, but no rice is exported. The cultivation is successfully carried on by East Indians.

COTTON.

The cultivation of Sea Island cotton was tried some years ago. It was not successful in Trinidad, and barely profitable in Tobago, even in good years. The Tobago planters struggled on, and succeeded in making small shipments every year.

For about five years, Mr. Thornton, one of the planters in Tobago, has been carrying out experiments in the hybridization of cotton, crossing the Sea Island with a native variety. Latterly, he has been assisted by the Government of Trinidad and by the British Cotton Growing Association, in producing seed of this hybrid. As the result of this, seed has been distributed free to planters in Tobago and Trinidad, and about 120 acres of this cotton are at the present time under cultivation. Very favourable reports have been received of the quality of this cotton, and members of the Conference will have an opportunity of inspecting the growing plants and the cotton produced by them.

TOBACCO.

A hybrid tobacco, introduced by Mr. Thomas Thornton, is under field trial in Tobago, and on a smaller scale in Trinidad.

STOCK FARM.

The Government Stock Farm in Trinidad has been in existence since 1879, and was first started to supply pure milk to the hospitals. This milk-supply has been continued to the present time.

The improvement of local stock by the importation of well-bred animals is another important feature of the Farm.

There are over 500 head of cattle on the Farm, and the following pure breeds are included : Zebu, Red Poll, Holstein Jersey, Hereford, Guernsey, and Shorthorn.

Mule-breeding has lately received more attention than formerly.

There is a branch of the Farm at Tobago, where stud animals are kept.

Facilities for Large Scale Experiments.

The Government is fortunately the owner of a cacao estate, at Diego Martin and of an estate at St. Augustine formerly cultivated in sugar. On these estates, field experiments on a large scale can be undertaken. St. Augustine is very conveniently situated near the St. Joseph Railway Junction, and experiments with seedling canes, rubber, camphor and fodder plants are being made there.

Forestry.

Local timbers have for many years been brought to the notice of foreign users by means of exhibitions, but with the exception of cedar shipments, the export trade is not of much importance at present. There are still strong hopes of a future in timber, and the Forest Officer, the Department of Agriculture and several planters are giving serious attention to the extension of the cultivation.

Among imported trees, Honduras mahogany has shown very successful growth, and in recent years the Government of British Honduras has generously assisted this Colony in obtaining a supply of reliable seeds.

Local timber trees are being planted fairly extensively.

Agricultural Education.

This was started in the primary schools in 1900, and the principles of agriculture are now taught in all schools. School gardens for demonstration purposes form part of the scheme.

The teachers received special courses of instruction in 1900. As these courses were necessarily short, it was decided to give the young teachers passing through the Training School a much longer course. This is now done at the Government Laboratory, and about twenty teachers attend there annually.

Higher agricultural education was introduced into the colleges in 1905, for students in the senior classes. About sixty attend the courses of instruction given at the Laboratory. The schedule for this subject is divided into two parts. The first part is concerned chiefly with the applications of chemistry and physics to the problems of the growth of crops, and the second part with the biology of farm crops and weeds.

Agricultural shows are frequently held, and these are a most valuable aid in agricultural education. Wonderful and rapid improvement in the quality of ground provisions has resulted directly from these shows.

The Instructors of the Board of Agriculture have educated large numbers of small cacao proprietors, by means of visits to their holdings and practical demonstrations on the spot.

Recently, efforts have been made to give estate instruction in cacao cultivation to young men at River Estate, and to introduce Home Reading Courses for persons already employed on estates. An examination on these Reading Courses recently held has shown that beneficial results can be obtained by this means.

The Bulletin and Circulars issued by the Department and

the Board assist in the dissemination of agricultural information. They are distributed free to local planters. A list of these publications is appended.

I may mention, in conclusion, that owing to the numerous educative influences now at work in this Colony, prominent among which are Clergymen of all denominations, agriculture has ceased to be unpopular with the rising generation. Our efforts to make it not only popular, but profitable, must be continued; we are really only at the beginning of a broad and great educational movement for promoting directly and indirectly the welfare of the people of this Colony.

LIST OF AGRICULTURAL BULLETINS AND CIRCULARS RECENTLY ISSUED IN TRINIDAD.

Bulletins Nos. 61 to 69.

Special Bulletin :—

Annual Report, 1910.
" " 1911.

Rubber—Trinidad and Tobago.
Tobago as a Field for Cotton Cultivation.

Circulars :—

No. 1. Cacao Circular.
2. The Carpenter Bird and Cacao.
3. Courses of Reading and Examinations in Practical Agriculture.
4. Strongylus Parasites in Cattle.
5. On Spraying Froghoppers.
6. The Froghopper Fungus and its Practical Application.
7. The Improvement of Sea Island Cotton by Hybridization.
8. Results Obtained in the Study of the Froghopper during the Wet Season of 1910.
9. The Palm Weevil as Sugar-Cane Pest.
10. Special Cotton Seed.
11. Short Hints on Cacao Cultivation for Peasant Proprietors.
12. Notes in connection with the Good Cultivation of Cacao.
13. Hints to Peasant Proprietors. A Quarterly Calendar of the necessary work on a Cacao Plantation.

Circulars issued by the Board of Agriculture :—

1. Life-History and Control of the Cacao Beetle.
2. Report of the Mycologist for the year ending March 31, 1911; Part I, containing the Reports of the Entomologist, Assistant Entomologist and Secretary.
3. Insect Notes for the year 1910-11. Miscellaneous Notes.
4. Report of the Mycologist for the year 1910-11, Part II.
5. Preliminary Notes on some Insects affecting the Coconut Palm.
6. The Cotton Stainer Bug.

Any discussion on Professor Carmody's paper was reserved for an ordinary sitting of the Conference. At its conclusion, The PRESIDENT mentioned the names of the Honorary Member of the Conference and the visitors (see list above), and welcomed them on behalf of the delegates. He also stated that, through the courtesy of the Chairman of the Victoria Institute, all the meetings will take place in the Hall of the Institute, instead of in the Chamber of the Legislative Council, which His Excellency the Governor had kindly placed at the disposal of the Conference.

The PRESIDENT also announced, further, that, owing to the confusion that exists in entomological and mycological scientific names in relation to plant pests and diseases, it would be advisable to take advantage of the presence of the several scientific officers so that they might confer together with a view to arriving, if possible, at some definite understanding as to the terms best suited for use in West Indian publications. He would therefore appoint the following gentlemen as a committee to consider and report on that subject:—

Mr. Guy A. K. Marshall, Scientific Secretary of the Committee of Entomological Research (Chairman); Mr. A. W. Hill, M.A., F.L.S., Assistant Director, Kew Gardens; Professor J. B. Harrison, C.M.G., M.A., Director of Science and Agriculture, British Guiana; Mr. W. G. Freeman, B.Sc., A.R.C.S., F.L.S., Assistant Director of Agriculture, Trinidad; Mr. J. Birch Rorer, A.B., M.A., Mycologist, Trinidad; Mr. F. W. Urich, F.E.S., C.M.Z.S., Entomologist, Trinidad; Mr. G. E. Bodkin, B.A., Economic Biologist, British Guiana; Mr. A. H. Kirby, B.A., Scientific Assistant, Imperial Department of Agriculture; Mr. H. A. Ballou, M.Sc., Entomologist, Imperial Department of Agriculture; with Mr. F. W. South, Mycologist, Imperial Department of Agriculture, Secretary.

Attention was drawn by The PRESIDENT to the fact that excursions which had been arranged by the Organizing and Reception Committee of the Agricultural Society were set down on a programme that had been distributed, but he wished specially to mention that, through the courtesy of the Hon. Thomas Cochrane, they were invited to proceed on Friday morning, by the R.M.S. 'Balantia', which had been specially chartered for the purpose, to Point Fortin, to see the oil fields there and to be the guests of Mr. Cochrane.

The PRESIDENT drew attention to the programme of proceedings of the Conference, and announced that the regular business would be taken up on the following morning at 9 o'clock.

The Conference then adjourned to enable the Representatives to attend a reception and garden party at Government House.

The programme of the papers to be read during the different sessions was placed in the possession of members; the papers were not, however, necessarily taken in the order there indicated.

At the commencement of each session, printed abstracts of the papers to be read were circulated among members.

In the evening, at the Victoria Insitute, a lecture on Colour Photography, illustrated by lantern slides, was given by Mr. J. B. Rorer, Mycologist to the Board of Agriculture, and a series of lantern views of Some Agricultural Activities in Trinidad was shown by Mr. W. G. Freeman, Assistant Director of Agriculture, Trinidad.

His Excellency Sir George Le Hunte, G.C.M.G, accompanied by Lt. Bindley was present, and the audience which was a thoroughly appreciative one, consisted mainly of the Conference delegates together with members of the Board of Agriculture and the Agricultural Society.

Dr. WATTS, in a few opening remarks, said that perhaps it might be asked what had colour photography to do with agriculture? Personally, he could say it had a very considerable application to it: and he hoped that by the time Mr. Rorer had finished, everybody would be imbued by the idea, if not personally to carry it out, to see at least that colour photography was within his reach.

An account of the address, furnished by Mr. Rorer, is as follows:—

COLOUR PHOTOGRAPHY.

Your Excellency, Mr. President, Ladies and Gentlemen: Within comparatively recent years such rapid advances have been made in photography, and so many of the photographic processes have been simplified, that a camera of some kind has become almost a necessary adjunct in every household. In scientific work, photography is indispensable and no laboratory is complete without its cameras, lenses, enlarging and photomicrographic appliances. Bulletins and circulars, especially those dealing with agricultural matters, are often replete with illustrations made from photographs which not only add to the interest, but sometimes are indispensable to a clear understanding of the text.

Of course the chief drawback in ordinary photography is the lack of colour; everything must be expressed in black and white. It is true that by the use of panchromatic plates and screens the relative values of different colours can be very accurately rendered, nevertheless the colours themselves are lacking.

Although colour photography may be said to date back to the beginning of the last century, when Goethe made experiments by throwing a spectrum from a prism on moist chloride of silver and noting the effects of the different colours, it was not until 1904 that we were able to obtain direct transparencies in colour on a photographic plate by a moderately simple process. The method. which was first perfected by Messrs. Lumière, of France, has since been followed by others, so that now there are a number of colour plates on the market, and the making of a colour picture has become

a much more simple operation than most people suppose. As yet, the process of getting a colour print is a very tedious one, but it can be done fairly accurately by the so-called bleaching out process made use of by Dr. J. H. Smith of Zurich, the inventor of the Utocolor paper. There is no doubt that in time this process of printing will be simplified just as has been the colour plate process.

The rendition of colours on a Lumière plate is made possible by the fact that all colours are either primary colours or made up of these colours, and is due to the screen with which the glass is coated before the sensitized panchromatic film is laid on. This colour screen is built up of starch grains dyed with the three primary colours, red, green, and blue-violet, and are used in the proportion of four green, three red, and two blue. The grains are of ordinary potato starch, varying in size from ·01 to ·02 mm. in diameter. On the plate there are about 4,000,000 to the square inch. The plate is put in the camera with the glass side toward the lens, so that all light before reaching the sensitized film, must pass through the coloured starch grains.

As a result of this the following phenomena occur when such a plate is exposed in the camera: the rays from a red object for example, will only pass through the red grains, for they will be absorbed by the green and the blue, so that only those particles of bromide of silver in the sensitive film which are beneath the red grains will be acted on by the light. If such a plate were developed and fixed in the ordinary way, the silver over all the red grains would be blackened by the developer and that over the green and blue would be unaffected but would be dissolved in the fixing bath, so that when viewed as a transparency the plate would be bluish green, the complementary colour to red, because no light would pass through the red grains masked by the blackened silver. If the object photographed is green, the rays will be absorbed by the red and blue grains; and the film behind only the green elements will become acted on by the light, so that after development and fixation the plate will show a purple-red colour—the complement of the green. And so with a blue object. As all colours are made up of these three colours in various combinations and proportions, the rays from different coloured objects will pass through the grains in exactly the proportion that they contain the different colours, so that the developed and fixed negative will always show the object in the complementary colours. To get the picture in its true colours, a very ingenious method has been devised. If, after development, but without fixation, the negative be placed in a reducing solution, the blackened silver will be dissolved while that not acted upon by the light on the developer will remain unchanged. If the plate is then exposed to daylight, the sensitized film which previously had not been acted on either by light, developer or reducer will become affected and will become blackened if the plate is again placed in a developer. The image will then be reversed and the picture will appear in the colours of the objects photographed.

Transparencies made by this process are as a rule a little dense for use as lantern slides, but are invaluable as a record of colour. They can also be used for three-colour blocks for illustrations.

If I may now have the lights put out I will exhibit some slides which will give you an idea of the range and delicacy of colours which can be obtained on the Lumière plates, and will show you the value of this process in natural history work much better than I can tell you.

The following slides were then thrown on the scene:—

1. Photomicrograph of the Lumière colour screen made on a Lumière plate.
2. Poinsettia plant.
3. Dark-red coleus plant in yellow urn.
4. White Hall and Archbishop's house, Trinidad, with Poinsettia in foreground.
5. Red and yellow cacao pods.
6. Section of shaddock, showing the delicate, pink-coloured flesh.
7. Different varieties of coffee berries.
8. A collection of beetles ranging in colour from yellow to blue.
9. Sugar-cane moth borers.
10. Moth of the wild silk worm of Trinidad.
11. Nodes of striped Selangore and Cavengery canes.
12. Nodes of D. 4805, D. 2468 and Crystal canes.
13. Old English lustre pitcher.
14. Chinese embroidered bag.
15. Rust on Guinea corn leaves.
16. Anthracnose of avocado.
17. Bunch of bananas showing some fingers ripening prematurely as a result of disease.
18. Government House, Trinidad.

DISCUSSION.

Dr. WATTS said he thought, after what Mr. Rorer had shown them, they would be ready to admit that the process was very simple. They had seen pictures of general interest, besides those of botanical, scientific and mycological interest, all of which indicated in a very remarkable manner how one could procure in a very short time records that were reasonably permanent and accurate, as regards colour as well as form, in a way hitherto unapproachable. They were indebted to Mr. Rorer for bringing the subject to their notice, and particularly for indicating its simplicity. He was sure Mr. Rorer would be prepared to answer any questions as to colour photography: how it was to be done, and its cost, etc., if anyone desired to ask him these.

In reply to a question from a member of the audience, as to how long a Lumière plate could be kept.

Mr. RORER said he had kept them, in Trinidad, for two or three weeks. By storing them in a refrigerator, they could be kept for a month after receiving them. When the weather was very damp they spoiled more quickly than in a dry season, but if kept sealed they would last for a month without losing

any of their qualities. He advised that they should not be opened unless they were to be used promptly.

Mr. ROBER, on being further questioned as to the temperature at which the development should be done, said that this was between 60° and 65° F. He had developed one or two with ordinary tap water in Port-of-Spain early in the morning. He preferred to use iced water, because the development could be timed more accurately. In reply to another question, Mr. Rorer said the exposure must be longer than is the case with ordinary plates. It was impossible to take snapshots, or pictures of moving objects, by the colour process. Under the most favourable conditions, three or four seconds was the shortest exposure that could be given: whilst in laboratory work, exposure of some five minutes was necessary. It was preferable, in taking objects outside, to choose a day when the sun was not shining brightly, for in the latter case a sort of pinkish shade is likely to be obtained. The prices of plates was rather high compared with that of ordinary plates, but they were not beyond the reach of people working in scientific spheres. At any rate they were not extravagantly expensive. A quarter-plate cost 9s. per dozen, and larger sizes in proportion. When one became accustomed to the process there was no need to spoil a plate.

AGRICULTURAL ACTIVITIES IN TRINIDAD.

The following account of Mr. Freeman's lecture, as well as the particulars of the discussion above, is taken from the *Port-of-Spain Gazette* for January 25, 1912: –

Mr. FREEMAN next gave a sketch of some agricultural activities in Trinidad. He said he was afraid that the slides he had to show would be rather second fiddle, coming after the excellent ones with which Mr. Rorer had entertained them, but he would endeavour to give them an idea of some of the activities that were going on in Trinidad at the present time. The first one showed a phase recently manifested in Trinidad; it was a view of their new possession (laughter), and the picture gave a general impression of it (the new island) as one passed by on a steamer. The next slide, for which he was indebted to Mr. B. H. Stephens (President of the Victoria Institute) showed the crater on the new island. Of course he was sensible of the fact that those were all phases of non-agricultural activities in Trinidad. Government House, St. Anns, and the adjoining grounds were next thrown on the screen, and then came a series of views depicting methods of grafting and spraying. Matters concerning the banana were next brought into view, and the manner of preparation for importation of Hevea seed at St. Clair followed. The audience was then led, by means of slides, to St. Augustine Estate, where banana cultivation was seen, as well as that of hybrid cotton. The cocoa-nut cultivation in the lagoon known as Nariva Cocal was next dealt with, and here the lecturer took opportunity to make known the fact that the high road in this neighbourhood runs on the beach, and is maintained by the Public Works Department, the maintenance consisting chiefly of removing the debris which floats in from the Orinoco. (Laughter.) The cocoa-nut cultivation at

Laventille, which was some time ago infected with bud rot, formed the subject of another view, and the remains of the old sugar works at River Estate next engaged attention.

Various other scenes were projected, the closing picture being a photographic group of the prize winners in the recent Cacao Competition, a picture which the lecturer said, fully indicated how cosmopolitan Trinidad was.

VOTE OF THANKS.

Sir FREDERICK CLARKE said he had great pleasure in proposing a vote of thanks to Mr. Freeman for the interesting and instructive slides they had seen; and he felt perfectly certain that the delegates attending the Conference would be only too pleased to visit many of the places which they had seen in the photographs. He also asked them to thank Mr. Rorer for the display of colour photographs given by him.

Mr. SANDBACH PARKER said he had very great pleasure in seconding the vote of thanks. They had witnessed the pictures with very great interest, and the delegates would make every use of the opportunities afforded them of visiting the places that had been shown on the screen.

The proceedings then came to a close.

On the next day, Wednesday January 24, demonstrations of methods of trapping cacao beetles and of spraying cacao were given at the St. Clair Experiment Station, by Mr. P. L. Guppy and Mr. J. B. Rorer, respectively. In regard to the former subject, Mr. Guppy first of all pointed out the usefulness of birds and lizards in keeping the cacao beetle in check. He made acknowledgment to Messrs. W. C. Jardine. Couva; H. Hutton, Caroni; and H. C. Warner, Carapichaima, for the receipt of much useful information with respect to the matter in hand, and then proceeded to enumerate the chief plants on which the cacao beetle is known to feed, namely Chataigne Maron (*Pachira aquatica*), Silk cotton (*Eriodendron anfractuosum*), Immortel (*Erythrina* spp.), Ochroe (*Hibiscus esculentus*), Forest mahoe (*Sterculia caribaea*), and Guimauve (*Malachra capitata*), of which the first is favoured most by the insect—a circumstance that makes it particularly useful for the purpose of trapping this pest. Stress was laid upon the matters that are of chief import in the control of the cacao beetle, namely: co-operation among planters, in adopting measures for destroying the pest; constant observation of chataigne planted to provide trap wood, on account of the liability of this to become injured and thus provide places for the beetles; the employment of good cultural methods, in cacao plantations, as a concomitant to the proper means of destroying the beetles, in order that the trees may be maintained in a healthy and resistant condition. After hearty thanks had been accorded to Mr. Guppy for his useful demonstration, Mr. J. B. Rorer, as has been stated already, proceeded to give a demonstration of methods of cacao-spraying, drawing special attention to machines that, after long trial, were stated to be most useful for the purpose. Hearty thanks were also given to Mr. Rorer for his practical and instructive demonstration.

ABSTRACT OF PROCEEDINGS.

The next session of the Conference was held at 1 o'clock on the same day (Wednesday, January 24).

CACAO.

The first paper was eutitled Methods of Spraying Cacao, by Mr. J. B. RORER, A.B., M.A., Mycologist, Board of Agriculture. Trinidad. An abstract of this is as follows :—

Although the control of various fungus and insect pests by the use of fungicidal and insecticidal mixtures applied in the form of a spray has become a routine part of the management of almost every farm and estate in temperate climates, but little use has been made of this method of control in tropical countries.

A series of experiments was started in Trinidad two years ago, in order to ascertain whether or not some of the common fungus and insect pests of cacao could be controlled by spraying, and whether or not this work could be put on a practical basis from the estate owner's point of view.

While the experiments were being carried on, a scientific study of the parasitic fungi and insects of the cacao tree was undertaken. It was found that, of the insects, the cacao beetle and thrips were causing the most damage, while the pod rot and canker diseases, both now known to be caused by the same parasite, *Phytophthora Faberi*, comprised the most serious fungus pest.

It has been amply proved that all these troubles can be economically controlled by proper spraying. The cacao beetle wi l not feed or lay its eggs on branches which have been sprayed with arsenate of lead ; thrips can be killed by the use of kerosene emulsion, lysol, or a lime-sulphur mixture ; while the black pod rot can be greatly reduced, the yield of good cacao increased, and canker infection prevented, by spraying with Bordeaux mixture. The experiments have also shown that spraying can be done at a cost which is not prohibitive, and which is more than compensated for by the increase in yield, even in the first year.

It must not be forgotten, however, that spraying is a preventive means of control, and to be effective must be done thoroughly and in good season, and with adequate machines and properly prepared mixtures. Spraying after the greater part of the damage is done is like locking the door after the horse is stolen.

A paper on Fungus Diseases of Cacao, by Mr. F. W. SOUTH, B.A., Mycologist on the Staff of the Imperial Department of Agriculture, was then taken, of which the following is an abstract :—

Previous to the year 1909, our knowledge of cacao diseases was far from complete, while much confusion existed as to the monology of different forms of diseases in different countries, and as to the precise identity of the organisms responsible for them. Since then, a large amount of information has accumulated, which has served to elucidate the position to a marked extent. The paper of which this is an abstract aims at giving an account

of our present knowledge. It is divided into three parts. The first deals with the diseases from a general point of view and describes their symptoms and treatment, the second gives some account of general estate sanitation, and the third deals with more definitely mycological subjects. As a certain amount of confusion exists in the popular names of cacao diseases, more especially the pod rots and root disease, new names for these have been proposed. In order to make the present position as clear as possible a tabular diagram has been drawn up, presenting a list of the diseases with their old and new names, the names of the fungi now held responsible and those of the parasites formerly supposed to be the cause, or the synonyms formerly employed. The first part of the paper alone need be dealt with in this abstract, as it includes the majority of points of general interest. Only the advances on our former knowledge of cacao diseases can be considered here.

The first of these is the recognition of the identity of the fungi described under the names *Macrophoma vestita*, *Diplodia cacaoicola*, *Botryodiplodia elasticae*, *Lasiodiplodia* sp., *Lasiodiplodia theobromae*, and *Diplodia rapax* as well as many others, and the discovery of the ascigerous stage of this fungus, called by Bancroft *Thyridaria tarda*, of which Hevea is the most important host after cacao. Accompanying these discoveries has been the increased tendency to believe that this fungus is not nearly of as great importance as a parasite as it was once thought to be. This work is associated with the names of Griffon and Maublanc, Mrs. van Hall, and Drost, Petch and Bancroft. An even more important step is the recognition of *Phytophthora Faberi*, as the true cause of canker both on cacao and Hevea, of its occurrence on Hevea fruits as well as cacao pods, and of its spread from cacao pods to the cushions and stems. This work, conducted by Rorer and Petch, has relegated to the position of pure saprophytes the numerous species of Nectria and related genera with their various Fusarium and other conidial forms, that were once thought to be responsible for the disease. Following on this work and closely associated with the control of canker and Phytophthora rot, has been the valuable series of experiments on spraying cacao conducted by Rorer in Trinidad. Undoubtedly, this is the most important means of controlling these diseases. It is, however, doubtful if so much emphasis need be laid on the uselessness of removing diseased pods, as is done by Rorer; Petch in Ceylon still recommends this course.

Another important addition to our knowledge is the elucidation by van Hall and Drost of the nature and cause of the witches' broom disease in Surinam and of the means by which it can be brought under control. The Surinam disease is different from that described by von Faber from the Cameroons and attributed by him to *Exoascus Bussei*. Attention may also be called to the fact that recent work has indicated that one of the forms of root disease of cacao and of other plants is due to a species of Rosellinia and that this disease is apparently not the same as that described by Howard and Auchinleck from Grenada. The question of root diseases in the West Indies will receive more attention in another paper.

Among minor alterations may be noted the inclusion of two new pod diseases. The first, due to *Colletotrichum Cradwickii* was described by Bancroft on specimens from Jamaica. The second, anthracnose, has not, so far as the author is aware, been described previously. It is in need of more thorough investigation, as also is the condition known as male cacao, which is associated, as in anthracnose, with a species of Colletotrichum. A peculiar blackening of beans in San Thomé has been described by Guéguen. It is due to a fungus *Acrostalagmus Vilmorinii*, forma *Thomensis*, that obtains access to the beans through the tunnels made in the pods by the shot borer, *Xyleborus perforans*. It may also be noted that pink disease has been found to occur on pigeon peas in St. Lucia, and that thread and horse-hair blights attack nutmegs in Grenada and spread from them to cacao. Finally a seedling disease has been found in St. Lucia which resembles in some points one described by Massee on seedlings grown at Kew from beans received from Jamaica and Dominica.

Such are the principal points in our increased knowledge of cacao diseases. In conclusion, it may be said that this increase has, in the West Indies, been attended by decrease in prevalence, owing to the growing recognition on the part of planters of the importance of the remedial measures recommended for combating the diseases.

The following table, summarizing the position as to the known causes of the chief cacao diseases, accompanies the above paper :—

Present Name.	Old Name.	Causative Fungus.	Cause formerly supposed* or former synonym†.
STEM DISEASES.			
Canker	...	*Phytophthora Faberi*	**Nectria theobromae*, Massee; *Calonectria flavida*, Massee, etc.
Chupon wilt	...	*Phytophthora Faberi*	...
Die Back ...	—	*Thyridaria tarda*	†*Diplodia cacaoicola*
Stem Disease ...	—	*Thyridaria tarda*	†*Lasidip'odia* sp.
Witches' Broom (Surinam) ...	...	*Colletotrichum luxificum*	**Exoascus theobromae*, Rit. Bos.
Witches' Broom (Cameroons)	...	*Exoascus Bussei*, Von Faber	...
Pink Disease	...	*Corticium lilacino-fuscum* B. and C.	...
Thread Blights ...	...	Various: *Pellicularia Koleroga*, Cke., *Coprinus* sp. etc.	...
Horse-hair Blight ...	...	*Marasmius equicrinis*, Müll.	...
ROOT DISEASES.			
Thyridaria Root disease	Root Disease	*Thyridaria tarda*	**Macrophoma vestita*, Prill. and Delacroix; *Lasiodiplodia* sp.; *Lasiodiplodia theobromae* Griffon and Maubl.
White Root disease ..	Root canker (Grenada)	Unidentified	...
Black Root disease ..	...	*Rosellinia* sp.	...
Brown Root disease ...	...	*Hymenochaete noxia*, Berk.	Identity uncertain
POD DISEASES.			
Phytophthora Rot ...	Black rot in the West Indies; Brown rot in Ceylon	*Phytophthora Faberi*, Maubl.	†*Phytophthora omnivora*, De Bary
Thyridaria Rot ...	Brown rot in the West Indies	*Thyridaria tarda*, Bancroft	†*Diplodia cacaoicola*, P. Henn.
Anthracnose	...	*Colletotrichum* sp.	*Lasiodiplodia theobromae*, Grif. and Maubl., etc.
Jamaica Pod Disease	...	*Colletotrichum Cradwickii*, Bancroft	...
Hardening of Pods ...	...	*Colletotrichum luxificum.* van Hall and Drost	...
Hardening of Beans (San Thomé) ...	...	*Acrostalagmus Vilmorinii*, forma *Thomensis*, Guéguen	...
Seedling Disease ...	...	*Ramularia necator*, Massee, etc.	..

The following is an abstract of the third paper in the series—Cacao Canker, by Mr. E. ESSED, B.Sc. (It should be stated that this abstract was prepared by the author of the paper before he had been led to modify several of the statements in the original, after consultation with Mr. J. B. Rorer and other mycologists at the Conference.)

Having occupied myself for a long time with a most careful investigation of Canker, I arrived at conclusions, which go far to show that the disease, of which canker is only a symptom, is caused by a Nectria of which *Spicaria colorans* is one of the forms of fructification; but that this particular symptom only develops when the tissues are, as it were, prepared for it, by what may be called a *predisposing moment*; and this may be: 1st, excessive moisture, as was asserted by Mrs. van Hall; 2nd, Phytophthora, as is shown by Mr. Rorer's experiments; 3rd, any other cause of reduction of the plant's vitality.

The facts, 1st that canker arising from pegmatia—gummy substance, of Mrs. van Hall—forming in the intercellular spaces and cells of the bark and imparting to it the peculiar colour; 2nd, that in nearly all cases the cambium underlying the cankered area is destroyed, giving rise to a space between wood and extracambial tissues, which is partly filled with pegmatia; 3rd, that the water brought on from the vessels through the medullary rays is simply poured out in the cavity, softening the pegmatia into a reddish, gelatinous mass; 4th, that the softening goes on through the intercellular spaces, setting up a tension in the tissues, which results in cracking of the bark; 5th, that through these or pre-existing cracks the transfusion of the reddish, gelatinous mass takes place—bleeding stage; 6th, that these effluxes being pegmatia give rise to chlamydospores or a mycelium producing Spicaria and Fusarium fructifications (*Spicaria colorans*); all these facts provide ample proof of the connexions between *Spicaria colorans* and canker. Mr. Rorer, concluding that Phytophthora is the cause of canker, was led by a wrong interpretation of facts. Operating with trees in the field—a proceeding which does not afford, from a purely scientific point of view, reliable and convincing results—he assumed that Spicaria appearing 'in cracks of bark about point of inoculation' was a: 'saprophyte quickly following.' But the Spicaria did not follow; it was in the bark before the introduction of Phytophthora. This was proved in the following way: Seedlings raised from selected seeds, taken from absolutely healthy pods—proved by microscopic examination—and kept under rigorously sterile conditions, were inoculated with Phytophthora and with Spicaria separately. Results of Phytophthora inoculation: one plant after a week showing signs of disease; the young leaves wilting and one blotched on the lower part. Two days after plant dying: aspect of 'Chupon wilt'; bark discoloured from 2 centimetres below inoculation spot to the top. Outlines of discoloration irregular, fringed; colour, in the middle brownish, along the margins like the skin of a cooked potato, a shade between grey and yellow. Not the slightest resemblance to canker. Other plants, the same discoloration but area affected considerably smaller and they did not die. Results of Spicaria

inoculation: At the end of a month no external change whatever; but sections reveal the presence of hyphae in tissues, here and there pegmatia forming. Two of these plants re-inoculated with Phytophthora developed reddish discoloration of bark, marked off from the healthy tissues by a thin but distinct brown line of wound cork; it was developing canker, so beautifully figured by Mr. Rorer. Pegmatia were to be found all over and cultures produced Spicaria and Phytophthora.

The parasitism of the Nectrias I found to be of a remarkable kind. As was hinted at above, they may grow in living tissue without doing any damage—a case of *symbiosis*; they may slightly interfere with the assimilation of the host; i.e., they become *isotrophytes*: incipient or abortive cases of canker, very frequently met with in Surinam and Trinidad; they may go a little further, suppressing growth or inducing abnormal growth; so becoming *atrophytes* or *hypertrophytes*—the cankered area being an instance of atrophy, and the wound cork of hypertrophy; in the end they may exhibit kteinophytic habits, killing the entire host plant. This pleomorphic parasitism of the Nectrias is shown in many other cases, as the little-leaf disease and root rot of the cocoa-nut tree, the first being a demonstration of the atrophytic, the second of the chemophytic habit of a Nectria. The discoloration is due to the formation of pegmatia in the tissues, and the death of the tree to these pegmatia seriously interfering with assimilation and water transport in the plant, the latter causing the withering of the leaves from the tips downward and their falling back against the stem—indeed, the very picture of the Panama disease as may be seen in my paper on this disease where a description of the pegmatia is also to be found.

The last of the papers dealing directly with diseases of cacao was presented under the title: A Possible Inference to be Drawn from the Studies on Cacao Canker, by Dr. A. Fredholm, and of this the following is an abstract:—

Although cacao canker has received considerable attention from phytopathologists, there is still a remarkable diversity of opinion as to the cause of this disease, though all are agreed as to the vagueness of the term Canker. The paper of which this is an abstract endeavours to harmonize the views of the different investigators without either reviewing or criticising the work upon which they are based. Descriptions of the symptoms and lesions are sufficiently concurrent in the different reports to indicate that the conditions described are identical, but there is a diversity of opinion as to the extent of the damage—whether it is confined to the stems and branches or extends to the pods also. Several organisms, either parasites or facultative parasites, have been found in connexion with the disease, and one worker regards one of these as the cause and the others as saprophytes, while another believes that one of the species included among the saprophytes by the first worker is the true cause of the disease.

It is more in accordance with the evidence deducible from the work of the various investigators to regard canker as a condition arising from the action of a parasite on the tissues

of the host, and not as a specific disease. This harmonizes the views of the different workers, since several parasitic fungi may be capable of producing the cankerous condition, according to the external conditions under which it is produced. Inoculations with one fungus may give positive, and with another negative, results in one locality, while in a different situation the results would be reversed. Such deviations from opinions held are not anomalous in pathology, and analogies from the study of human diseases are given in the paper.

If it is proved that different parasitic fungi can give rise to diseases involving cankerous conditions, then the comparative study of the symptoms of those conditions would soon lead to the discovery of differences by which the cause could be determined in each case; as a result several diseases could be described under specific names, all of which are now included under the term Cacao Canker.

In the discussion which followed, Mr. E. A. ROBINSON (Barbados) asked if the remedial measures that are recommended for fungus diseases could be depended upon to do what is expected from them even when the actual fungus causing the disease had not been identified, and was assured by Mr. J. B. RORER, that, as Bordeaux mixture is a general fungicide, confidence may always be placed in it, in the special connexion. In reply to a further question, he was also informed by Mr. Rorer that, as regards cacao canker, spraying with Bordeaux mixture is of no use in cases where the disease has already entered the tree; the matter of importance was that infection by canker takes place through the pod, so that spraying the pods is certainly an effective measure toward control. The PRESIDENT explained that the gist of Mr. Rorer's replies to Mr. Robinson was that, no matter what may be the character of the fungus causing the canker, the real point was that spraying with Bordeaux mixture is likely to be effective in controlling the disease. Planters were therefore well advised to continue to employ the remedial measures recommended to them, and to leave the mycologists to decide as to the fungus origin of the disease.

After Mr. J. B. RORER had dealt with several of the matters in Mr. E. Essed's paper, in regard to which these two investigators held different opinions, Mr. Essed replied. A question was then asked by Mr. D. S. DE FREITAS (Grenada) as to whether Forastero cacao is more resistant to canker than any of the other varieties, and he was answered by Mr. Rorer to the effect that he had never noticed any great difference in regard to the susceptibility of the different varieties, except that Alligator cacao was much more likely than the rest to be attacked, while Mr. J. JONES (Dominica) mentioned Forastero as quite susceptible, and Calabacillo as being less commonly affected by the disease.

In summing up the discussion, The PRESIDENT referred again to the practical importance of the possession of knowledge of remedial measures that are applicable, whatever the information as to the causative fungus may be, stating

at the same time that, as the ideas as to the causes of disease are quickly becoming more definite, so is this the case in regard to the remedies to be used and their manner of application. The keenness of different investigators to find the true causes of the manifestations of disease, and their anxiety to support the views that they had adopted as a result of their work, should form matters for encouragement to the practical planter.

Professor J. B. HARRISON, on the invitation of The PRESIDENT, exhibited illustrations, drawn from actual pods, of the varieties of cacao growing in British Guiana, with a view to ascertaining if growers of cacao in Trinidad and other West Indian islands could identify and classify them as distinct types and recognize them by their own names. When the illustrations had been shown, The PRESIDENT stated that they would be available, in a safe place, for closer examination on the part of those interested, with a view to the provision of information as to the identity of the various kinds portrayed.

After this, the reading of papers relating to cacao was resumed. The first of these was by Mr. P. L. Guppy, Assistant Entomologist to the Board of Agriculture, Trinidad, and dealt with Insect Pests of Cacao. An abstract of this is as follows:—

The pest first dealt with is the cacao beetle.

INTRODUCTION. Since Circular No. 1 of the Trinidad Board of Agriculture was issued, it is very satisfactory to have to record an increased activity in the campaign against the cacao beetle.

Thanks to Messrs Jardine and Hutton, I am able to give the remarkable results of the systematic collecting and trapping undertaken by these gentlemen, recorded in this paper.

DAMAGE DONE TO CACAO. It is difficult to estimate the actual damage done wherever the pest prevails, but from the number of dead branches, and occasionally a dead tree seen on old-established estates, and the miserable looking, distorted trees met with here and there, it is safe to say that thousands of dollars are lost annually in large properties where no proper and systematic control measures are adopted.

In young contracts where trees range from two to six years old, not only are many lost, but their retarded growth is also a heavy loss ultimately; young trees also take a bad shape or become disfigured from hacked up bark where worms or grubs have been cut out.

FOOD PLANTS. Besides Chataigne maron (*Pachira aquatica*), the favourite food plant of the pest, there are *Eriodendron anfractuosum* or silk cotton, *Hibiscus esculentus* or gemauve, and occasionally *Erythrina umbrosa* or Immortel.

Mr. A. B. Carr states that he also found this beetle attacking *Sterculia caribaea*, or forest mahoe, and *Couroupita guianensis*, or cannon ball tree.

PREDACEOUS ENEMIES. Birds and lizards must be protected. It is well known that some birds are shot down mercilessly and *paid for* because a few dozen pods are lost annually in some

places; birds like the King of the Woods (*Momotus swainsonii*) and some of the woodpeckers have suffered most from persecution in this respect. The protection of lizards is quite as important, especially those that climb and creep along the branches of trees.

CONTROL. The following traps have been found most practical and effective :—

(1) Suspended traps.
(2) Bark traps.
(3) Fork and leaning traps composed of bark and branches.

(1) The suspended traps are composed of short portions of branches about 2 feet long and from 2 to 4 inches thick. Several of these should be hung about open spots wherever beetles are suspected.

(2) The bark traps are merely portions of bark stripped off in lengths rather low down the tree where the bark is thickest. The beetles lay freely in fresh pieces of bark which soon dry up and become hard, and eggs and larvae die from want of nourishment; this saves expense of collecting and destroying wood.

(3) Fork traps simply mean pieces of chataigne placed between forks of trees. Either portions of branches or pieces of bark can be used, the longer pieces being placed on the ground leaning against trunks of cacao trees, to be used as leaning traps.

In regard to the use of these traps, certain spots in the fields can be made more attractive to the beetles for setting the traps.

Spots are chosen at intervals throughout the estate and some cutting away is done that will let in more light; to effect this, a little pruning always attracts beetles. On such cleared portions traps must be set both at the root, and the fork of every second or third cacao tree.

From the time that a chataigne tree is wounded it becomes not only an attraction for beetles seeking food, but also for egg-laying purposes. Trees therefore from which trap wood has been cut must be regularly visited.

Locality.	Date.		No. of days.	No. of beetles.	Average per day.
	From	To			
Caroni	Aug. 23, 1911	Sept. 18, 1911	26	5,324	204
	Sept. 18, 1911	Sept. 24, 1911	6	2,117	333
		Total	32	7,441	232
Caura	June 17, 1911.	Oct. 14, 1911	119	10,408	87

It is very important that chataigne trees growing near, or on, cacao estates should be kept under close observation. Where-ever branches are broken by accident or other causes this damage is sufficient to attract the beetles. Such branches must be cut away from the trees, and the wounds on the stem dressed in the same way as is recommended for the cacao trees.

Chataigne trees that are ring-barked, for the purpose of destroying them, afford an especial attraction to beetles; such trees should therefore be systematically examined every day.

At Caroni one man was employed and the cost of taking 7,441 beetles was about $10·00. In Caura it cost $45·00 to destroy 10,403 beetles.

FINAL RECOMMENDATIONS. (1) It is absolutely necessary for planters to co-operate, in order to work effectively against the pest. (2) There is no difficulty about catching and destroying the beetles, and the cost is small. Chataigne can be easily obtained and the planter may be able to devise improved methods of trapping. (3) Don't use chataigne as shade for cacao.

The second pest to receive attention in the paper is thrips of cacao.

The Board of Agriculture's Circular of February 24, 1911, by Mr. F. W. Urich, deals with cacao thrips (*Heliothrips rubrocinctus*).

There is at present an extensive and severe epidemic in the Sangre Grande district; this has been going on for some time past and seems to be still spreading. Spraying with kerosene emulsion is being carried out on some estates. Although trees severely attacked recover, yet the excessive loss of leaf causes reduction of crops.

Dry weather conditions are favourable to increase; although unshaded fields seem to suffer most, it is quite possible that the trees under such conditions may finally become more resistant to thrips by becoming hardier.

There are a large number of cashew, almond (*Terminalia Catappa*) and mango trees in the Sangre Grande district and these are infested with thrips, especially the first-named, which is the favourate food plant of the pest.

Small leaf-eating beetles (*Neobrotica* spp. and *Colaspis* spp.) have again become very troublesome; as soon as young cacao leaves are put forth they are reduced to a 'ragged' untidy condition by the beetles feeding on them.

In Sangre Grande district this has caused a severe strain on the trees; after loss of leaf caused by thrips the fresh crop of tender leaves is attacked by these pests. Spraying with arsenate of lead is recommended.

The paper then deals with podhoppers.

In certain localities podhoppers (*Horiola arcuata* and allied species) are sufficiently numerous to cause a certain amount of damage, but this happens only where the ants, principally those of the genus Azteca, are abundant.

These ants build their carton nests over the podhoppers and prevent the hymenopterous parasites from getting at the eggs.

To control the pest, the ants must first be destroyed ; recom mendations are given in Circular No. 3, Board of Agriculture pp. 5, 6, and 15.

ADDITIONAL OBSERVATIONS. Finally, the following additional observations are given.

There are of course a great many other cacao pests in Trinidad, but so far the above-mentioned may be reckoned important.

Fortunately, the planter has a great many insect friends which act as natural controlling agents.

In certain instances the upsetting of the balance of nature has been the cause of trouble to planters, such as the killing of birds and the introduction of the mongoose, and to a great degree the clearing of forest lands.

After the reading of the paper, Mr. GUPPY, in reply to a question by Mr. G. G. AUCHINLECK (Grenada), stated that he had noticed the attacks of thrips to be worst in the case of cacao under shade. Mr. E. A. ROBINSON (Barbados) had found that the attacks vary—sometimes being worst without shade, and sometimes where it is present ; in answer to The PRESIDENT, he said he thought, in any case, that dry weather conduced to an increase of the pest. The matter was advanced further by a statement from the Rev. Dr. MORTON (Trinidad) to the effect that thrips is likely to do most damage on the lower lying lands. Mr. H. A. BALLOU stated that thrips was naturally more injurious, generally speaking, after the removal of shade, because the insect favours sunlight ; the question of the removal of shade was concerned with the balance between the advantages resulting from it and the damage that might result from attacks of thrips, under the altered conditions.

Mr. P. L. GUPPY further stated, in answer to Mr. J. R. BOVELL (Barbados), that no natural enemies of thrips had been so far found in Trinidad ; the best remedial measure appeared to be spraying with kerosene emulsion. In regard to the question of the existence of natural enemies of the pest, Mr. F. W. URICH (Trinidad) stated that a parasite of the pear thrips had been discovered quite recently, in California, where the parasitism had been as much as 70 per cent., and that a favourable feature of the matter was that the host belongs to the same genus as the cacao thrips in the West Indies, so that its introduction, which would be brought about at an early opportunity, was likely to be successful. After The PRESIDENT had laid emphasis on the importance of the existence of such a parasite, the Hon. D. S. DE FREITAS (Grenada) stated that, in his experience, in Grenada, thrips occurs on cacao whether shade is present or not, but that he had found the best remedy in proper cultivation, draining and manuring ; the provision or otherwise, of shade did not seem to be the controlling principle. This evidence was supported by Mr. W. N. SANDS (St. Vincent). Mr. W. E. BROADWAY (Tobago) described his experience of the matter, which showed that, in Tobago, shade encourages the attacks of thrips.

At the conclusion of this part of the discussion, The PRESIDENT drew the attention of the delegates to a paper by

Mr. J. JONES, on Grafted Cacao at the Dominica Botanic Station, which had been published in the last number of the *West Indian Bulletin*, copies of which were in the hands of members, stating that the subject was intended for discussion at the Conference In connexion with the matter, The PRESIDENT asked Mr. Jones to state if anything definite had been done in the direction of crossing different varieties of cacao, and in reply the information was given that such crosses had been made, employing Alligator cacao, and that it was proposed to cross-pollinate two varieties of Forastero cacao. The PRESIDENT drew attention, further, to the importance of the fact that when a highly desirable type of cacao had been produced by crossing, this could be propagated, with certainty as to the nature of the resulting plants, by grafting—a matter that possesses a most important bearing in regard to the development of the cacao industry.

Mr. A. W. HILL (Kew Gardens) stated that he had seen the grafted cacao at the Dominica Botanic Station, and spoke in high terms of the conduct of the work and of the results that are being obtained. He predicted a great future in the matter of the utility of cross-pollination, in cacao, and hoped that, in addition to the production of good types in this way and their propagation by grafting, work would be done in the direction of obtaining seedling grades of cacao, especially in view of the fact that vegetative propagation cannot be depended upon to produce plants of the same type for an indefinite period. The subject of the establishment of plantations of cacao containing plants of a uniform type received attention from Mr. E. A. ROBINSON (Barbados), who drew attention to the risk of the total destruction, by some specific disease, of the trees in such a plantation, and the advantage that accrues from the possession of plants of mixed types, in that the flowering and fruiting of the different kinds do not take place all at the same time, so that there is an economy in the provision of drying space.

After Mr. JONES had stated in reply to the Hon. J. G. W. HAZELL (St Vincent) that he had not been successful in budding cacao, in Dominica, the Rev. Dr. MORTON, (Trinidad) advocated the claims to utility, in commerce, of a hardy, strongly bearing cacao, rather than anything of a highly specialized type—at any rate, until results of a very definite nature had been attained from grafting—and suggested that such a type might be produced in practice by rigid seed selection and the constant removal of inferior plants as soon as their nature was shown. The Hon. D. S. de FREITAS asked if fine quality of the product, productivity of plants, or power to resist disease, was the chief characteristic to be aimed at, in producing new types of cacao. In Grenada, it had been found best to grow the commoner kinds on the low-lying lands—kinds that are very resistant and productive. As far as Grenada was conerned, the Calabacillo had proved the most useful; in any case, he did not think that any type would show itself to be suitable to all kinds of soil conditions.

Mr. W. G. FREEMAN (Trinidad) drew attention to experiments that are being conducted in Trinidad for the purpose of determining whether seed selection or grafting is likely to produce the most desirable cacao plant. He also asked if

anyone in the West Indies had tried to replace old cacao trees by crown grafting, as was done in temperate countries for fruit trees, or if grafting was done on chupons, or suckers. In replying to this, the Rev. Dr. MORTON stated that he did not know what had been done in these ways, but that he did not think that old trees or small branches should be employed for the purpose, but that what are called 'renews'—that is, new shoots that arise near the ground and suggest a new tree—should be used. By the employment of these, a quick-growing shoot, independent of the parent plant could be utilized. In regard to the matter suggested by Mr. FREEMAN it was the opinion of Mr. FISHLOCK (Virgin Islands) that there is no reason why cacao should not be grafted in the tropics in the same way as that employed for the propagation of apples, pears and peaches, in the temperate regions; it was this speaker's opinion that the aim should be to produce good types of cacao, suitable for different districts, and then to propagate them by grafting.

A paper dealing with Manurial Experiments on Cacao in Trinidad was prepared for the Conference by Mr. J. DE VERTEUIL, F.C.S., Assistant Analyst, Department of Agriculture Trinidad, of which the following is a short abstract:—

Manurial experiments with cacao are being carried out by the Department of Agriculture and the Board of Agriculture; in the first case these are conducted together with experiments to ascertain the effect of removing shade, and that of permitting chupons, or suckers, to grow to different extents. The work of the Department of Agriculture, in this connexion, is conducted at the River Estate and at the Brooklyn Estate, as well as on four estates in Tobago. The similar investigations under the auspices of the Board of Agriculture are being carried out on nine cacao estates in Trinidad.

Detailed tables of the results of the experiments under the Department of Agriculture are given in the paper, and these show, on the whole, that the effects of manuring are favourable as respects the yield of cacao. As regards shade, the best returns have been obtained under conditions of no shade followed in order by those of partial shade and of complete shade.

The trials dealing with the results from the removal of chupons have not been conducted long enough for any definite statements to be made concerning the matter; statistics are included in the paper for the purpose of future reference.

As the experiments under the Board of Agriculture have only been commenced lately, no records of yields under the different conditions are yet available.

In addition to the numerical results of the trials that have been obtained so far, the paper presents tables giving information regarding the constitution of the soils employed for experimentation.

An abstract of a paper, prepared for the Conference, on Manurial Experiments with Cacao in Dominica, by Mr. H. A.

TEMPANY, B.Sc., Superintendent of Agriculture for the Leeward Islands, and Mr. J. JONES, Curator of the Botanic Station, Dominica, is as follows :—

Manurial experiments with cacao have been carried out at the Botanical Station, Dominica, since 1902-3, and have been systematically reported on each year. The original series consists of five plots varying in size between 0·28 and 0·37 of an acre and situated on level ground in the Botanic Station.

The manurial treatment received by the plots is as follows: (1) no manure; (2) basic phosphate, 4 cwt. per acre, and sulphate of potash, 1½ cwt. per acre; (3) dried blood, 4 cwt. per acre; (4) basic phosphate, 4 cwt., sulphate of potash, 1½ cwt., dried blood, 4 cwt., per acre; (5) mulched with grass and leaves.

The manures are applied once a year, and each of the plots has received the same manurial treatment each year. The material of which the mulch is composed consists largely of grass from lawns, and leaves and pods of the Saman trees surrounding the lawns; it is applied at the rate of four baskets per tree.

The accumulated results show that the most profitable returns are obtained from the use of the mulching method, which throughout the course of the experiment has given consistently higher yields than other forms of manurial treatment. On the mean of nine years' results, this method has given an average annual gain over the no-manure plot of 5·57 lb. of cured cacao per acre, and a profit from manuring of 218*s*. 6*d*.

Next after this plot 4, which received a complete manure consisting of dried blood, potash and phosphate, has given the largest yield; on the average return the annual gain over the no-manure plot amounted to 430 lb. of cured cacao per acre, and a profit from manuring of 133*s*. 9*d*.

In the case of the other two plots, in which phosphate and potash, and phosphate alone, respectively, were applied without nitrogen, the gains have been smaller.

Additional experiments have, since 1907, been carried on at the Botanic Station, with a view to testing further the value of the mulching method and also other points of importance. Plots F and G, each ¼-acre in extent, have been mulched with grass and leaves and manured with cotton-seed meal respectively. The situation and condition of the plots admit of their comparison with the no-manure plots in the older series, and the results of four years' experience has been once again to demonstrate the value of the mulching method of maintaining and increasing fertility; cotton-seed meal on the other hand has maintained, but not increased, the yield.

Plots H and I are situated on the steeply sloping hillside, similar to the conditions under which much of the cacao in Dominica is grown. Plot H received no manure, while Plot I was mulched with grass and weeds in the customary manner. The plots have a horizontal area of 0·414 acres in the case of Plot H and 0·878 acres in the case of Plot I.

Four years' work on these plots has now clearly demonstrated the value of the mulching method when applied to hillside conditions, as is shown by the returns which as a mean of 4 years show an average annual gain over the no-manure plot amounting to 693 lb. of cured cacao per acre and a pecuniary profit valued at 286*s.* 6*d.* per acre.

In relation to cacao cultivation, attention was drawn to a paper dealing with the Estimation of Certain Physical Properties of Soil, compiled from the work of various investigators by Mr. G. G. AUCHINLECK, B.Sc., Superintendent of Agriculture, Grenada, and printed, with a note by Mr. H. A. TEMPANY, B.Sc., in the *West Indian Bulletin*, Vol. XII, No. 1.

A description of the Barnard cacao drier, by the inventor Mr. G. Barnard, was prepared for the Conference, and the following extract, describing the machine, is taken from this:—

The Barnard cacao polisher occupies a ground space of 8 feet by 3 feet, and consists of a hollow cylinder made of wood or iron, through which runs a shaft on to which are keyed a number of eccentrics; attached to the lower or under side of these eccentrics are feet or pedals, jointed to give a rocking motion as the eccentrics rise and fall. Hard rubber pads are attached to the bottom of these pedals which give under pressure to prevent the beans from being crushed; an additional safeguard against crushing is that the pedals do not come within 2 inches of the cylinder and are spaced sufficiently far apart on the shaft to allow the cacao to stir about freely and become thoroughly mixed as the pedals rise and fall alternately.

The cylinder and shaft are run in opposite directions, so as to insure the thorough stirring of the beans, in order that each bean shall get an equal amount of polish. The cylinder is driven at the rate of ten revolutions per minute, and the shaft at sixty to eighty. At this rate of work the machine polishes one bag (200 lb.) of cacao in ten minutes—a record unobtainable by the present method, using the human foot. The Park machine is driven by belting from the 2½ power engine which drives a Gordon's Patent Dryer of eight bags capacity, but the patentee has arranged for hand gear to be attached to smaller machines (of 2 or 3 pedals) to be worked by one man.

The cacao is fed to the polisher and damped (just as at present) before starting, and on removal is placed either in the sun or trays, or direct into the dryer.

The remaining paper in this section was entitled The Structure and Pollination of the Cacao Flower, by Messrs J. JONES, Curator of the Botanic Station, Dominica, and G. A. JONES, Assistant Curator. It has been abstracted as follows:—

After a description of the flower of the genus Theobroma has been given, an account of the time and manner of opening of the cacao flower is presented. An attempt to ascertain the percentage of pollination of flowers gave, in the first observations, 1·4; but it is likely that this amount is too high, in the

light of subsequent experiments and of the results of investigations made by Wright.

In considering the natural means for the pollination of the cacao flower, it is held that its structure renders self-pollination almost impossible; nor did very close examination show that it was likely that pollination is brought about by any process of a mechanical nature: the low percentage of pollination supports this view. Further, the structure of the flower indicates that it is quite unsuited for wind pollination, and actual experiments are described which show that such pollination is unlikely to take place. This brings matters to a consideration of the only remaining means, in nature, for effecting cross-pollinnation, namely that of insects. Among the latter, bees, moths, butterflies, beetles and flies are not seen to visit cacao flowers, and the latter do not possess either scent or nectar which might attract such insects. The forms usually seen in cacao flowers are of the nature of mealy-bugs, thrips, aphis and others similar, and those mentioned are seen to be carefully nursed by ants, especially the red ant. In regard to this matter, experiments in which flowers were kept free from the visits of insects of the first-mentioned kind showed that no pollination took place under the circumstances. The same was the case when these insects were introduced by hand, and ants were excluded, even though the insects had crawled about on the flowers. This fact, together with the circumstance that microscopical examination did not show the presence of pollen grains on the bodies and legs of any of these small insects, has led to the conclusion that, in Dominica, they possess little, if any, direct power to cause pollination of the cacao flower. The conclusion is reached, after close and continued observation, that this is brought about by ants when acting as nurses to the insects mentioned; though it is not claimed that definite conclusions have been obtained as to the way in which the pollen reaches the stigma of the cacao plant.

The work described has led to experiments in the cross-pollination of cacao, and hybrids have been obtained between selected Forastero and Alligator cacao. It is hoped to be able to produce, by a further selection on Mendelian lines, a plant with the vigour and disease-resisting power of the selected Forastero, and bearing beans of the Alligator type. For the purpose of hastening the fruiting period, several of the young plants have been grafted on to Calabacillo stocks, and these are being compared with other, similar seedlings, planted in soils as controls, for the purpose of determining whether maturity is actually hastened by grafting, or by the fact that the scion is taken from mature trees.

The Conference then adjourned for luncheon.

SUGAR.

Upon the resumption of business, The PRESIDENT said:—

The proceedings this afternoon are concerned with questions relating to sugar, and I propose to take first those papers which deal with sugar-cane experiments. I have been asked, however, before this is done, to submit a Resolution to this Conference which will be moved by Mr. Sandbach Parker

and seconded by Sir Frédérick Clarke, having reference to the Brussels Convention. I will read the Resolution and then ask those gentlemen formally to move it. There has been a free consideration of the subject outside the Conference, and with the object of keeping the matter within bounds, I should be glad if there be no discussion except by those who may be against it. The Resolution is as follows :—

'Whereas substantial benefits have been conferred on the British West Indian Colonies by the operation of the Brussels Convention :—

'*Be it resolved*: (1) That the members of the Conference view with dismay the threatened withdrawal of Great Britain from the said Convention and express the earnest hope that this course may be avoided, feeling convinced that the said withdrawal will be disastrous to the sugar industry and the general prosperity of the West Indies.

(2) 'In view of the meeting of the Brussels Convention on the 29th instant, that a copy of this Resolution be sent to His Excellency the Governor with the respectful request that it be forwarded immediately to the Secretary of State for the Colonies.'

Mr. C. SANDBACH PARKER (England): Before moving this Resolution, I should be very glad if I may express my appreciation of the honour which has been done me in allowing me to propose it, because I feel that the future welfare of the West Indies is intimately connected with the question which forms the basis of this Resolution. I move the Resolution with a deep sense of its paramount importance, not only to the sugar industry but to the general welfare and prosperity of the British West Indies. Notwithstanding the splendid work done for the minor industries after the recommendations of the Royal Commission of 1897, I feel that sugar is, and must be, the backbone of agriculture in the West Indies, and that anything that affects its stability must have an effect upon the whole welfare of these Colonies. It is an industry for which most of our British West Indian Colonies are eminently suited, and I cannot help asking myself whether it ever struck those who were foremost in criticizing the condition of the sugar industry in the British West Indies previous to the Commission of 1897, that sugar was the one industry and the staple product of practically every important island in the Caribbean Sea, and the true reason why it languished in the British West Indies was that they, unlike their neighbours, had no secure market for their sugars, and therefore could offer no inducement to capitalists to invest money in improved methods of manufacture. Since the passing of the Brussels Convention, confidence has been slowly restored and capital has been cautiously feeling its way again in the British West Indies. Now we are seriously threatened as to whether the Sugar Convention is to be continued after 1918, and the whole of the progress is greatly endangered by the threatened withdrawal of Great Britain from the Convention, in 1913. There will be a meeting of the Conference next week, at Brussels, to discuss the question if Russia is to be allowed to

export more sugar than is permitted by the terms of the Convention, and I understand, and, in fact, it has been stated in Parliament, that the Imperial Government will withdraw from the Convention unless that permission is given. I venture to think that we, as representing the whole of the West Indian agricultural industries assembled here to-day, may, without any political bias whatever, send our views to the representatives of the Government in London, in the hope that they might realize the conception that exists on this side of the ocean with regard to its effect on the welfare and prosperity of these Colonies. And, therefore, in asking you to support this Resolution, I ask you to do so, not by a majority, but unanimously. As far as I know, there is not a man in this hall who will not be benefited by supporting this Resolution, and therefore, I ask you to support it unanimously, and to sign the Resolution with your own names as delegates, in order that we may follow up the cable which we ask His Excellency the Governor to be good enough to send to-day, by forwarding the Resolution so signed, by next mail. This cannot fail to have considerable weight with His Majesty's Government, and I only hope that it might result in something being done to prevent the abandonment of a policy which has been of such inestimable importance to us all in the British West Indies. (Applause.)

Sir FREDERICK CLARKE (Barbados): I have much pleasure in seconding this Resolution, and before I say anything in regard to it, I desire to express the thanks of the delegates, assembled here, to the President for having allowed us to bring up this matter, which is not on the programme. The Legislatures and the Agricultural and Commercial Societies of the various West Indian Colonies interested in sugar have passed either Addresses or Resolutions on this subject; but a Resolution passed to-day by the representatives of those islands, assembled here, must have more weight than Resolutions passed by the various colonies; and it is for that reason that I feel particularly grateful to the President of this Conference, for having allowed us to bring on this matter to-day. I think I should add, however, that as this is a West Indian Agricultural Conference, any matter which affects agriculture, and especially a subject which so deeply concerns agriculture in the West Indies, could not be out of place at a Conference of this sort. No matter what debatable ground we may have to tread on, it is our duty and the duty of our President, to have a matter of this kind discussed at this Conference. The Resolution states that we view with dismay the threatened withdrawal of Great Britain from the Convention. We all know what that withdrawal will mean to these colonies; we know what was the condition of these colonies before the coming into operation of the Brussels Convention; we know that there was no confidence in the sugar industry; that our machinery was antiquated; that plantations were being abandoned, and those that were not abandoned were changing hands at the price of scrub lands, and the labouring classes in these colonies were, many of them, without employment, and in an abject

state of poverty. I remember, when the Royal Commissioners visited Barbados in 1897, that I was told by one of them that in some of the islands they had visited nothing could have been more pitiable than the condition of the labouring classes. Let us contrast with that the condition of these islands within the last few years. We have no such abject poverty as then existed. We find the price of land going up; we find enormous sums of money being invested in new machinery. Surely there must have been some cause for the restoration of that confidence in the sugar industry. Do not let anyone say it is a mere coincidence. A thing like that could not have happened without some direct and controlling cause. Therefore, I say we are quite right in stating that we view with dismay the threatened withdrawal of Great Britain from the Convention. It is needless for me to say more. I have great pleasure in seconding the Resolution. (Applause.)

The Resolution was put and carried with applause.

The PRESIDENT: We will now take first those papers relating to sugar, and which deal with sugar-cane experiments. I propose to group these papers on sugar-cane experiments together, and then have a discussion on them.

The first paper taken was entitled Outline of Manurial Experiments in Sugar-cane in Trinidad and Tobago, by J. DE VERTEUIL, Assistant Analyst, Government Laboratory, Trinidad, and of this the following is an abstract:—

Manurial experiments on sugar-cane are being made on four estates. These experiments are under the control of the Board of Agriculture. Nine plots are maintained on each estate. Each plot is approximately one acre in extent so that there are 9 acres under experiment on each estate, or 36 acres in all.

The following manures are being used: basic slag, bone meal, superphosphate of lime, sulphate of potash, sulphate of ammonia, nitrate of soda, calcium cyanamide, calcium nitrate, temper lime and air-slaked lime. Two plots on each estate are treated with the manures generally employed on the estate. The manures are supplied free of cost to the proprietors at their railway station, but the cost of application and the cost of general cultivation are borne by the estate owners.

On two of the estates, B. 156 was planted in October 1910, and on the other two, D. 109 in October 1910. The manures were applied in June 1911.

On two of the estates the fields under experiment had received applications of pen manure at the rate of about 10 and 5 tons respectively. No pen manure had been previously applied to the fields on the other two estates.

The canes will be reaped during the coming crop season, and the weight from each plot recorded.

After the reading of this paper, an address was given by Professor J. B. HARRISON, Director of Science and Agriculture, British Guiana, on the Results of Experiments with Sugar-cane in British Guiana. In introducing the subject, Professor Harrison explained that he was unable to provide any formal

presentation of the results, owing to the fact that the abnormal weather had prevented the conclusion of the experimental work for the season. He referred to the information that had been given by him at the last Conference, in 1908, making allusion specially to his description of the chemical changes that take place in the soil, in British Guiana, through the long-continued cultivation of the sugar-cane, under different conditions of manuring. It was an interesting fact that the ultimate result was the production of the condition that characterizes the almost sterile land in the arid districts of the world—and that in heavy clay land in the wettest parts of British Guiana. The ultimate effect was the production of alkaline and exceedingly saline soils. Professor HARRISON thought that some doubt had been expressed at the Conference mentioned as to the way in which the matter was being treated by him. Subsequent investigation had, however, supported the opinion that, in land deficient in humus and organic matter, the soil waters in time lost their lime and there was a concentration of magnesium carbonate in such waters. The fact was that the lime went out of solution during drought and was replaced by excesses of magnesium and sodium carbonate. In soils in which cane would not grow, not only were these substances found, but an excess of magnesium chloride as well. Flooding had been found useful in ameliorating the condition, and the investigations provided an explanation for the reason of this.

Professor HARRISON gave an outline of the method of experimentation with sugar-cane that had been adopted in British Guiana, stating that it consists of the duplication and re-duplication of experiments under a recognized system of laws, and arranged under such conditions of control as will give the most effective results. After mentioning several important details with regard to the way in which such investigations should be carried on, Professor HARRISON referred to the work that was being conducted in British Guiana, in relation to the raising of varieties of sugar-cane from seed, stating that this has been continued but that no striking results have been achieved lately. A past extension of the work had been efforts in the direction of obtaining what may be termed 'control' seedlings, but this was now replaced by what is known as the Java, or more properly the Drumm, system. In this, the canes were recorded by means of their appearance, rather than by figures expressed in tables, and the investigations were assisted by the making of water colour drawings of the different kinds of canes; further, since Mr. Sahasrabuddhe had visited the Colony, a suggestion of his had been adopted in addition, namely the making of photographs of certain of the varieties, special record being taken as to the nature of the buds produced by the different kinds. The subject was complicated by the way in which canes showing different characteristics were produced by one definite kind, by vegetative reproduction; for instance, a cane after the type of D. 625 had at first produced a certain kind of red ribbon cane, and in the third year it gave rise to five different kinds of canes. It had been suggested that the good characteristics of different sorts of cane, including the Bourbon, should be com-

bined in one in which no alteration would arise from mutation. It did not seem possible to the speaker to do this; the proper method appeared to be to combine the desirable characters of different seedlings, and then to take advantage of the existence of mutation, and if possible to fix the result subsequently by Mendelian methods.

In regard to manurial experiments with varieties, a departure from the old custom had been made. This was to use the newer varieties for comparison, to a great extent, instead of the White Transparent and the Bourbon. There were two reasons for this: firstly, that certain of the new varieties possess a different power to use up the nitrogen of the soil, and the added nitrogen in the manures, from that exhibited by the White Transparent and the Bourbon; secondly, it had been found that, when variety canes are grown under differing manurial conditions, with nitrogenous manures in varying quantities, a better guide to the relative value appears to be obtained by taking the mean results instead of making comparisons with the conditions of no manure or fairly heavy manuring. The results in such work had not been as high as was desirable, on account of interference by drought. A matter of interest had, however, been brought forward by the work, and that was the successful production of canes, starting with D. 625, that possess a high vegetative figure and a fairly high sugar content, the latter being 15 to 20 per cent. (and possibly more) greater than that of the parent D. 625.

After making reference to the Bourbon cane, and comparing it with the best seedlings that had been produced, particularly in regard to susceptibility to rind disease, Professor HARRISON gave attention to trials of molasses as an application to sugar-cane lands, stating that the results which had been obtained so far had not shown that there was any actual increase of yield on account of the employment of the molasses. Further than this, a large number of determinations of the sugar content of the canes indicated that there was virtually no difference in it, whether molasses was used or not. The upshot was that it had been shown that the application of molasses to soils, for sugar-cane growing, is certainly not a commercial success.

Mr. J. R. BOVELL, Superintendent of Agriculture, Barbados, followed with an account presenting A Comparison of Some Seedling Sugar-canes with the Bourbon variety in Barbados. The comparison was made on the basis of experience in Barbados during the past fourteen years with the Bourbon cane, the White Transparent, and the seedling canes B. 208 and B. 147. The first substitution, in any quantity, of White Transparent and seedling varieties, for the Bourbon, was made at the close of 1895, on account of the short crop of that year, caused chiefly by the attacks of red rot (*Colletotrichum falcatum*) on the Bourbon. The comparisons are made with the canes mentioned, grown in the same field for the period of fourteen years, the work being done at Dodds, where the average rainfall for the period was 56·39 inches. In spite of the fact that the planting material invariably consisted of sound,

healthy cuttings from plant canes, the Bourbon has always, except for one year, been attacked more or less by red rot.

Detailed results of the experiments are given, and these serve to show that all the other canes, namely B. 147, B. 208 and White Transparent were superior to the Bourbon, and in that order.

The fact that some of the planters near Dodds had found by experiment that some of the seedling canes gave better results than the White Transparent (which had replaced the Bourbon) led them to increase the area in the best of these canes, until the White Transparent is no longer cultivated by them. In extension of the matter, therefore, the results are given that have been obtained with the White Transparent, B. 147 and B. 208 on a fairly large area at Carrington, for the four years 1903-6. These show, on the assumption that the yield from the Bourbon would have been in the same proportion as at Dodds, that all these canes would have been superior, in the order B. 147, B. 208 and White Transparent.

After a detailed consideration of the results at the two places mentioned has been given, attention is drawn to the fact that the White Transparent is not now grown at Carrington and certain neighbouring estates on which the sugar-canes are weighed and the juice analysed. It has not, however, been replaced generally by B. 147, on account of the poor ratooning quality of the latter, and the present likelihood is that its place will be taken by B. 6450—a seedling that has given exceptionally good results as plants in the black soils, and as plants and ratoons in the red soils.

Reference is made to repeated efforts in Barbados to re-introduce the Bourbon cane, all of which have failed, or are failing, on account of its susceptibility to red rot.

In concluding, the suggestion is made that whenever the growing of the Bourbon sugar-cane is advocated, the evidence that is adduced in favour of it should be based upon very definite results.

Mr. H. A. TEMPANY B.Sc., Superintendent of Agriculture for the Leeward Islands, followed with an account of the Sugar-cane Experiments in the Leeward Islands. An abstract of this is:—

The experiments with cane varieties have now been carried on continuously for twelve years under identical conditions of working. The experiment stations are situated in the fields of estates in different parts of the two islands, Antigua and St. Kitts. The canes are planted in rows across the field, each row containing a variety; they receive the same treatment as the canes being grown for the crop, so that the experimental results are directly comparable with those of the latter.

During 1910-11 the rainfall in Antigua was unfavourable, serious drought being experienced during the earlier part of the year; so that both plants and ratoons yielded poor returns, and the effect of the root fungus was increased.

The list of varieties under experiment contains forty-one, and is almost identical with that of the previous year.

The best results among plant canes have been given by B. 4596, Sealy Seedling, D. 1111, B. 1528, B. 306, D. 625, B. 208, B. 156, B. 376, B. 1355, D. 109, B. 6346, B. 6450, and B. 4507.

As with the general crop, the yields have not been large; that from White Transparent, the standard cane, has been exceeded by the returns from sixteen varieties. The cane giving the best results—B. 4596—produced 5,380 lb. of sucrose to the acre; its consistently good behaviour during the short period of its tests in Antigua should recommend it to planters for trial. The second place has been taken by the well-tried cane Sealy Seedling, with a yield of 5,330 lb.; while D. 1111 has come third with 5,060 lb.: this cane appears to be gradually adapting itself to local conditions. Another promising cane is B. 1528, the fourth on the list, with a yield of 4,950 lb. of sucrose to the acre.

When the results are compared according to the method introduced by Dr. Francis Watts, it is found that the upper third of the returns includes the following varieties: B. 4596, B. 1528, and Sealy Seedling, at eight stations; B. 306, B. 208, D. 109, B. 6450, and D. 625 at five stations: D. 1452, B. 6346, B. 4507, and B. 1753 at four stations; White Transparent, B. 147, B. 3696, B. 3675 and D. 848 at three stations

Among ratoon canes, B. 4596 again occupies the first place, with 3,750 lb. of sucrose per acre; satisfactory positions are also occupied by B. 208, B. 156, and B. 1528; D. 1111 is twelfth on the list, and again is improving its position, so that this forms another reason for the suggestion that it is undergoing adaptation to local conditions.

The method for comparison of behaviour at different stations, just employed for plant canes, shows that the following have been included in the upper third of the returns: B. 156 at six stations; B. 376, B. 109, B. 1528 and B. 3696 at five stations; B 4596, D. 116, Sealy Seedling and B. 298 at four stations.

Small yields have been obtained from ratoon canes in all cases, although these are greater than those of the previous year, in spite of the fact that the rainfall was more favourable in that year. A possible explanation of the circumstance is that the results may be due partly to the fact that the rainfall received by the canes as plants appears to affect to a marked extent their yields as ratoons.

The adverse effect during 1908-10 is due to the small rainfall of 1908-9, and this has made itself felt, notwithstanding the fact that the rainfall of 1909-10 has been much more favourable and has produced a good growth of plant canes.

In St. Kitts, the actual system is to cultivate the main collection of forty-two varieties at two stations, La Guérite and Molineux, as plant canes, and at the latter station as first ratoons; while at the remaining stations a selection of fifteen of the most promising canes is grown, both as plant and first ratoon canes. The weather experienced in the growing

season was somewhat unfavourable in the period April to July, especially in the cane-growing districts near Basseterre; while it was generally favourable in the latter part of the year. This circumstance has affected the returns in the experiments to some extent.

Among the plant canes the lead has been taken by B. 208 —a cane which in the past has demonstrated its suitability to conditions in St. Kitts. D. 625 and Sealy Seedling have come second and third. As neither of these canes has previously shown any particular promise in St. Kitts, their present position is probably due to variation in season. The succeeding canes are D. 109, B. 4596, D. 116 and B. 254; while B. 1753, which held the premier position last year, has fallen to the eighth place—as a result, probably, of variation in season, and partly of error of experiment; for in the western districts of the island, this cane has given satisfactory returns and is regarded favourably by planters. Among the ratoons for last season, the first is D. 625, followed in succession by B. 1753, B. 4596 and D. 109.

The results for the whole period of experimentation, namely eleven years, show that the first four canes are successively B. 208, D. 116, D. 109, and B. 1753, among plant canes. With ratoons the leading canes are similarly B. 1753, B. 208, B. 4596 and White Transparent.

The usual method of reviewing the results, namely by ascertaining which canes occupy the upper third of the different experiment stations has been adopted, as it affords a means of judging which varieties are suited to a wide range of conditions. The facts adduced in this way are as follows: among plant canes, B. 208 at six stations; B. 4596, D. 625 at four stations; Sealy Seedling, D. 109, D. 116 at three stations; B. 254 and B. 1753 at two stations

Among ratoon canes, B. 1753 appears first at five stations: D. 625, B. 4596, D. 109 at four stations; and B. 208 at two stations.

During the past year the work of cane experimentation has been extended to Nevis, on Pinneys estate, and it is hoped that the work in this direction will be increased in scope. Manurial experiments with sugar-cane have been conducted in Antigua and St. Kitts since 1899. They are carried out in the fields of estates in different parts of the islands in the same manner as are the variety experiments. In the past the trials have included experiments both with plant and first ratoon canes.

Earlier experiments have shown that, provided a good dressing of pen manure is given to plant canes, the subsequent application of artificial manures is not beneficial.

At the present time the experiments being conducted comprise a series of manurial trials on ratoon canes which have not received any artificial manures as plant canes. The series consists of thirty-three experiments on plots each $\frac{1}{40}$-acre in area, and comprising trials with varying amounts of sulphate of ammonia, nitrate of soda, vi-phosphate, superphosphate and sulphate of potash, in combination and singly. At present

the majority of the experiments have been repeated seventy-four times under varying conditions of soil, climate and rainfall, and the results can be regarded with some confidence.

The best results have been obtained with nitrate of soda and sulphate of ammonia applied in single doses and without other manurial constituents, at the rate of 40 lb. and 60 lb. of nitrogen per acre. Dividing the dose reduces the yield; phosphate and potash do not increase the yield; nitrate of soda has given better results than sulphate of ammonia.

The effect of the manures varies with the season; comparison with earlier results in which similar manures were applied to plots bearing plant canes reveals the existence of a certain amount of residual action which is felt in the following season. This holds good even in the case of nitrate of soda. The effect is intensified in seasons of drought.

The accumulated results of these experiments show that, in seasons of average rainfall, applications of quick-acting nitrogenous manures to first ratoons are beneficial.

As a result of ten years' continuous manurial experiments in the Leeward Islands, it appears that the limiting factor to the manurial requirements of cane lies in the water-supply available for growth.

Under the conditions obtaining in Antigua and St. Kitts this is only provided for by rainfall, and an application of 20 tons per acre of good pen manure, before the plant canes are established, provides sufficient plant food for the production of a crop of plant canes, first ratoons and possibly second ratoons. If it were possible to increase the available water-supply by irrigation, it seems probable that the manurial applications might profitably be increased, but under existing circumstances such increases are beyond the power of assimilation of the cane.

Applications of small quantities of quick-acting artificial nitrogenous manures to ratoon canes are of benefit in seasons of average rainfall, however, from the fact that they stimulate recovery from the check to growth, incident on the reaping of the previous crop.

During the past two years trials have been conducted with nitrolim (calcium cyanamide) and nitrate of lime. The series consisted of ten plots. The manures were applied singly, and in conjunction with phosphate and potash.

As a mean of twenty-four repetitions of each experiment, it appears that nitrate of lime has given satisfactory results when applied by itself; the results obtained are about equal to those given by sulphate of ammonia, but inferior to nitrate of soda. Nitrolim has not affected the yield. The opinion is expressed that its action is too slow to be of value to ratoon canes.

Molasses as a fertilizer for cane lands has also formed the subject of experiments. The trials are the outcome of the suggestion that applications of molasses may stimulate the development of organisms capable of fixing free nitrogen from the air, of the type of *Azotobacter chroococcum*. During the

past three years experiments to test this point have been in progress in Antigua. As a result of ten repetitions of each experiment, the opinion is expressed that such applications are not likely to be beneficial to ratoon canes.

Organisms of the type referred to exist in Antigua soils, but it appears that if the applications increased the nitrogen fixation, the constituent would not be in a form available for use by ratoon canes. More benefit may be expected from applications to plant canes; experiments to test this point are in progress.

Trials have been inaugurated to test whether advantage is likely to occur from treatment of cane soils with disinfectants, on the lines of Russell and Hutchinson's experiments. Only one trial has so far been made, and the results cannot be regarded as in any way conclusive. The result obtained was that a plot of ratoon cane, $\frac{1}{20}$-acre in extent, showed a gain of 2 tons of cane per acre after injection with carbon bisulphide.

Investigations have been made into the effect of small applications of lime on the action of artificial manures. The experiments are the outcome of the suggestion that soils markedly deficient in lime might be benefited by small applications of this substance, as nitrification might be interfered with owing to there being an insufficient supply of lime in the soil to neutralize the nitric acid formed in the process. During 1909-10 and 1910-11, a series of experiments was carried out in St. Kitts to test this point. In the three main series of manurial experiments the B plots were limed and the A plots were not limed. As a result of two years' experience, no appreciable increase of yield has been found to follow the application.

After the reading of these papers, The PRESIDENT invited discussion of the matters that had been brought forward.

It was stated by Mr. J. R. BOVELL (Barbados) that he was in agreement with Professor HARRISON'S statements in regard to the breeding of seedling sugar-canes. Professor HARRISON, in reply to Mr. F. W. SOUTH, stated that the varieties produced as the result of crossing D. 625 and D. 95 were attributable to vegetative reproduction. He further explained in answer to the Hon. J. S. HOLLINGS (Nevis), that the cane to which he referred as Bourbon was the Yellow Bourbon, and suggested that the reason why the true Bourbon had lasted so long and done so well was that it was being reproduced naturally, from time to time, by seed.

The next paper to be read dealt with the subject of Bourbon and Seedling Canes, by Mr. J. W. ARBUCKLE, Brechin Castle estate, Couva, Trinidad, and the following were the chief matters that were brought forward :—

The experience of the author with the Bourbon cane dates from 1873, at which time it was practically the only cane raised in Trinidad. It first showed signs of impairment of vitality in 1896, and serious attacks of disease exhibited themselves two years later. An attempt was made to cope with it by uprooting the affected canes and burning them, when the weather

permitted this to be done; if this was not practicable, a trench was dug 6 × 4 feet, into which the diseased canes were put and covered with 2 feet of earth. It was not possible to continue the experiment, on account of the rapid spread of the disease. A new method was tried, consisting in burning off the canes and replanting the fields in the following year with healthy Bourbon plants taken from a part of the estate situated at a distance of several miles, where there was no disease, only top plants being used. Though the canes sprouted well and grew to 4 feet in height, they were attacked similarly to the former.

In the two following years, White Transparent was used; but it was decided to replace this by others, owing to its somewhat unsatisfactory behaviour at the factory. The yield obtained from it was 40 to 55 tons per acre.

In 1904, another trial was made of the Bourbon cane, by planting it in lands where seedlings had been grown for four years without exhibiting any signs of disease. The experience with this was similar to that in 1898; somewhat better results were obtained with Bourbon in a second field. Later, the replanting of these fields with seedling canes under practically the same treatment as that for the Bourbon, gave yields of 40 tons per acre. A further trial with Bourbon, in 1906, was an absolute failure; though when it was followed by D. 116, 32 tons of cane per acre was obtained. The latest attempt to grow Bourbon cane was commenced in June of last year; at the present time the appearance of the plants is unhealthy, and the growth has been checked during the last two months of the year. It is not expected that any greater success will be obtained in this experiment than in the former ones.

The conclusion is reached that the abandonment of the Bourbon cane was justified, under the conditions. In its place, the following varieties have been of much use on the Brechin Castle estate: D. 95, D. 116, D. 625, D. 109, B. 347, B. 156. Of those, D. 95 gave the best results at first, but has since shown a marked susceptibility to attacks by the froghopper. With reference to these attacks, attention is drawn to the peculiar distribution of the pest in affected fields; the infestation occurs in patches which change their locality from season to season. Returning to the consideration of the seedlings mentioned, all except D. 95 are doing well on a large scale.

The important general conclusion in relation to the matter is that the return of sugar per acre on the Brechin Castle estate has increased rather than decreased since seedling canes, only, have been included in the cultivation.

At the end of this paper, Mr. A. P. COWLEY (Antigua) gave particulars of his experience with the Bourbon and seedling canes, and emphasized the usefulness and superiority of the latter, under conditions of which he had special and direct knowledge.

The next paper to be read was entitled The Application of Mendelian Principles to Sugar-cane Breeding, by Mr. F. W. SOUTH, B.A., Mycologist on the Staff of the Imperial Department of Agriculture. A synopsis of this is given here:—

The line of argument pursued in this paper is indicated by the following short statements of the subjects of the different paragraphs in the paper.

Introduction.

Difference between fluctuation due to environment and true variation, and between continuous and discontinuous variation or mutation.

Example of continuous variation and of regression in its inheritance.

Discontinuous variation and step mutations; the meaning of the terms 'breeding true' and 'pure line'.

The inheritance of discontinuous variations. Mendel's principles as applied to the inheritance of one and of two pairs of opposite characters.

The production of synthesized strains.

Apparent continuous variation produced by the interaction of several discontinuous determinants.

Suggested application of Mendel's principles to the case of the sugar-cane.

Some points requiring emphasis.

Forms of variation in vegetatively produced sugar-canes.

Absence of evidence as to the nature and inheritance of variation in the different characters of the sugar-cane, as contained in records up to the present time, and the reason for this.

Complex nature of the agricultural characters of the sugar-cane, indicating that they cannot be expected to behave as Mendelian units, and that a careful analysis of them is necessary.

Consideration of botanical characters frequently overlooked, and the probability that they vary discontinuously and will behave as unit characters.

Practical difficulties of hybridization work along Mendelian lines as applied to the sugar-cane.

Conclusion. Ignorance of the nature of variation in the different characters of the plant under consideration and of the inheritance of such variation; that is, the absence of the necessary analytical knowledge precludes the possibility of synthesizing desirable strains of sugar-cane. Under these circumstances, experiment station workers should be content to follow the methods of selection in use at present rather than to centre their attention on attempts at synthesis.

The acquirement of analytical knowledge should be the function of a special station instituted for the purpose in a suitable locality. Even if this failed to obtain results with economic characters, a clear understanding of the botanical characters would be of great service.

At the conclusion of Mr. South's paper, The PRESIDENT drew attention to the circumstance that the matters with which it deals open up what is practically a new line of work

for experimentation in the propagation of the sugar-cane; though he agreed with Professor Harrison that it does not seem possible to apply the principles at the present moment. Mr. G. N. SAHASRABUDDHE (India) then read a paper dealing with The Study of Sugar-canes with a View to Their Classification, in which the following points were brought forward :—

The attempts at classifying sugar-cane varieties, in spite of the vast importance of the subject, have been incomplete and unsatisfactory. The classification by Stubbs, by Cordemoy and Dekteil, and by Harrison and Jenman are based on colour of stem only. Harrison and Jenman have also grouped some of the varieties into appropriate types, according to their habit of growth and general appearance. Since the advent of seedling canes, the number of so-called varieties has increased enormously. How many of these are real varieties? Botanical varieties? Is it not possible to group these seedling varieties into types or botanical varieties as Harrison and Jenman have grouped some of the older varieties or as the various varieties allied to White Transparent are grouped together? It will be interesting to see which of the characters of cane are subject to fluctuating variability. Sucrose content varies. But to determine the varieties in morphological characters we require correct descriptions—botanical descriptions and not agricultural, at present supplied. The only such descriptions in English are those by Mollison and Leather, of varieties in India. In British Guiana, coloured sketches of a large number of varieties are preferred. But the sketches of those given by Noel Deerr in his book do not give any idea of the cane beyond the colour of the stem. Such sketches are always incomplete, difficult to make, difficult to copy. Accurate botanical description should include description of all parts, whether such parts are at present considered important or not. It should describe (1) colour of leaves, (2) shape, colour and height of stem, (3) shape, length and girth of internodes, (4) the structure and appearance of ring, upper band, root dots, and lower band of the nodes, (5) structure of the eyebud, (6) bloom, (7) structure and appearance of inflorescence. Eyebud is rather difficult to describe. A natural-sized photograph of the bud should accompany any description. Great care is necessary in selecting specimens for photographing. Such descriptions will enable us to find out those characters which are inherited, even when grown from seed. Colour and size of leaves vary. Colour of stem varies, but in some varieties the majority of seedlings inherit the colour of the parent. Up to this time striped seedlings have been rare and are of less vitality. This and some other facts show the striped cane is not the original of solid-coloured ones, as is supposed by some. The structure of node and eyebud is neglected everywhere. But as the cane has been propagated by vegetative methods for such a long period, can this not be the most important character which is stamped on the offspring? As far as I have seen up to this time, there are five types of eyebuds, which may be described as: (1) White Transparent type, showing flat, broad-pointed eyebuds, the point extending slightly beyond the ring, with a distinct channel of medium breadth and depth; (2) Bourbon type (with

possibly two anti-types) having broad, somewhat flat eyebuds, with the apex more or less pointed, but with an indistinct channel, the eyebuds being triangular; (3) White Tanna type, near to (2), but with the eyebuds more or less circular, and having the bud-tip near the top; (4) Meligeli type, in which the eyebuds are long, narrow and pointed, and extending beyond the ring, with a distinct deep channel; (5) mammary type, possessing circular eyebuds, without any channel, and having the bud-tip nearly in the middle. Present information shows that structure of eyebud does not appreciably change by soil or climate, also in bud variations. As regards seedlings, my observations are not wide enough, but they indicate that it is also a constant character inherited by offsprings from seed. This is not an unqualified statement. These points are brought before the Conference to elicit information which the outside world is expecting from the veteran scientists of the West Indies who have spent their lives with sugar-cane.

The following is a synopsis of the paper which was read next in order, namely Sugar-cane Insects in Trinidad, by F. W. URICH, F.E.S., C.M.Z.S., Entomologist to the Board of Agriculture, Trinidad :—

The paper gives attention to the following points :—

(1) Borers in stalk and root stocks.

The giant moth borer—*Castnia licus.*

The small moth borers—*Diatraea saccharalis* and allied species.

The weevil borer—*Metamasius hemipterus.*

The palm weevil—*Rhynchophorus palmarum.*

Difficulties in applying direct remedies. Natural control. Suggestions for co-operative investigations in Demerara and the West Indies, with a view of ascertaining status of natural enemies.

(2) Insects affecting the roots: froghoppers.

(3) Insects affecting the leaves: Delphax, caterpillars of moths and butterflies.

The next paper was read, in the absence of the author, by Mr. H. A. TEMPANY (Antigua). It was by Dr. A. URICH, Ph.D., F.I.C., Analytical and Technical Chemist to the Trinidad Estates Company. The following has been extracted from the paper, which was entitled A Quick Method for Estimating Moisture in Megass :—

The method, after a little practice, is very easy and safe, occupying about three quarters of an hour—actually twenty-five minutes for the distillation. The petroleum used is the kerosene oil imported into Trinidad, of 105° F. flash point. I use a flash with a short, wide neck (diameter of neck, 1¼ inch), of 300 c.c. capacity, charged with 25 grams of megass and 100 c.c. of petroleum. The flask is surrounded, once for all, with a well-fitting brass wire wove. Thus protected, it will serve for a hundred and more distillations. It is mounted on a tall retort stand which is placed on a small box, 10 inches high, to allow of a distance of almost 3 feet from the base of

the table. This height is necessary on account of the 50 c.c. measuring tube (graduated to $\frac{1}{10}$-c.c.) and of the long discharge pipe for the distillate. The flask is provided with a double perforated india-rubber cork, one hole to receive a thermometer with a legible paper-scale and the other for the rather narrow ($\frac{1}{10}$-inch lumen) glass tubing for the distillate. One leg of this tube is very short (2½ inches) in order to avoid premature condensation, but the other one, bent downwards at an inclined angle, is about 15 inches long, in order to discharge the condensed water and petroleum into the lower part of the graduated tube. This tube is inserted and held in a vertical position in a somewhat large glass cylinder holding about 2 litres of water, the large bulk of which admits of dispensing with a Liebig's condenser. The cylinder is placed on blocks of wood, and is only lowered gradually to the level of the table when the distillate threatens to close the end of the delivery tube.

The distillation progresses rapidly, and without any bumping, the thermometer indicating a temperature of about 220° F. for the vapours. Only towards the end of the distillation, the temperature rises suddenly and soon reaches 330° to 360° F. At the same time, white fumes are formed, and the distillation must be stopped by removing the lamp. By lifting the thermometer, which must move with gentle friction in the cork, having been coated with vaseline previous to starting the distillation, the re-entering of any liquid from the longer leg of the tubing into the flask is prevented. The measuring tube contains now, say, 13·8 c.c. of water and about 30 to 35 c.c. of petroleum, the latter holding in suspension about 0·1 c.c. more water, which will separate only after several hours. (This amount is fairly constant, if the work is always done under the same conditions.) Any small drops of water adhering to the walls of the measuring tube are brushed down by means of a small feather fixed in a long glass tube. Suppose 25 grams of megass has been taken and 13·9 c.c. of water obtained, the megass will contain 55·6 per cent. of moisture, or to be more exact, 55·4 per cent. as 13·9 c.c. of water at, say, 86° F., weighs only 13·85 grams.

The most reliable method is to work with 500 grams, or more, of megass as recommended by Watts and also by Heriot. The preliminary drying is done in a shallow tin box placed on the top of a steam boiler, followed by a final drying in a capacious stove—a process occupying, however, a whole day; an additional inconvenience arises from the smell of the pitch oil stove that has to be used for many hours, in a confined tropical sugar laboratory.

The two last papers dealing with matters connected with sugar were taken as read, for want of time. The former was entitled the Sugar Industry in Antigua and St Kitts-Nevis, by Mr. H. A. Tempany, B.Sc., Superintendent of Agriculture, Leeward Islands, and Mr. F. R. Shepherd, Agricultural Superintendent, St. Kitts-Nevis. It has been abstracted as follows:—

This supplements the account of the sugar industry of these islands, between 1871 and 1905, given in the *West Indian Bulletin*, Vol. VI, p. 373.

ANTIGUA. The succeeding period, 1905-11, is one of considerable development in the cane sugar industry of Antigua—a development which may be said to have commenced in 1903, with the abolition of the sugar bounties by the Brussels Convention. The altered circumstances have led to the erection in the island of two well-equipped, modern central sugar factories, and the introduction of other improvements in cultivation and manufacture. Later, in 1910, the capacity of the Gunthorpes factory was largely increased. It is estimated that these factories have a maximum capacity at the present time of 9,000 to 10,000 tons of grey crystals.

The exports of sugar from Antigua have varied from 10,006 tons in 1906 to 13,514 tons in 1910, with an increase to nearly 14,000 tons in 1907, dropping to 8,671 tons in 1909; the average production for the period mentioned is 11,622 tons. This exceeds considerably that of the period 1895 to 1904, but is largely short of the output in 1881 to 1894, when the average yearly export was 13,113 tons. It is claimed that the increased production, in the recent period of six years, over that of the preceding ten, is due almost entirely to the adoption of better methods of manufacture, for it has been brought about in the face of the severe economies of 1895 to 1903, which led to impoverishment of the soil; and in the face of other untoward conditions such as unfavourable rainfall and the increased incidence of root disease.

The introduction of central factories has caused an increase in peasant cane cultivation.

During the past twenty years the total cultivation in Antigua has not varied much. It is likely, however, that the adoption of the central factory system will lead to extension in the area of land thus employed.

The claim is made that the improvement in the past eight years has been abundantly demonstrated to be due to the introduction of central factories into the island.

ST. KITTS-NEVIS. The exports of sugar from this Presidency have varied from 15,196 tons in 1906 to 12,510 tons in 1910; there was a steady drop from 1906 until 1909, when an increase took place

The exports of sugar in 1905 were 20 per cent. greater than the average of the previous ten years. A reduction of the cane-growing area took place in 1907, chiefly in Nevis, but the crop of this year was still above the average. The figures show that, although during the past five years, cane cultivation has been decreased by 1,500 acres, the export of sugar continues to be much the same as the average of the previous ten years. This seems to indicate larger returns on the part of the new varieties than on that of the Caledonian Queen, grown formerly. This consideration has to be taken in conjunction with the circumstance of a decreased yield owing to the planting of intermediate crops of cotton. In St. Kitts, at present, there are about 7,000 acres of cane, and in Nevis approximately 1,500 acres. The returns are best in St. Kitts, on account of the more favourable rainfall and the more fertile and cultivable soil.

Negotiations have been completed for the erection, in St. Kitts, of a central sugar factory, which will be constructed in time to deal with the crop reaped in the present year; its maximum output will be 10,000 tons of grey crystals.

There is little peasant cultivation in St. Kitts, but much more in Nevis. The fact that the returns in the former island have continued to be better than those in Antigua is due partly to the more favourable rainfall and the superiority of the soil in St Kitts. The sugar industry in St. Kitts may be said to be in a satisfactory condition, and its prospects good.

Tables are given in continuation of those presented in the *West Indian Bulletin*, Vol. VI, p. 382, for the purpose of recording the total production from the sugar industry during the period under review.

The last paper intended for this session was entitled The Determination of the Water Content of Molasses, by H. A. TEMPANY, B.Sc., F.I.C, F.C.S., and V. M. Weil, B. Sc., Assistant Government Analyst, Antigua. It has been published in the *West Indian Bulletin*, Vol. XII, p. 89; an abstract is, however, furnished here:—

In the *West Indian Bulletin*, Vol. X, p. 29, some results were published by one of us, in conjunction with Dr. Francis Watts, of a number of analyses of samples of muscovado molasses from Antigua and St Kitts; in this work the water content was arrived at by means of the formula due to Heron. In this formula the specific gravity of a 10-per cent. solution is corrected for the presence of non-sugar solids, by deducting from it 0·95 × 0·8 of the per cent. of sulphated ash, the specific gravity of water being reckoned as 1,000; this corrected figure is the solution density of the organic total solids, which are then determined by means of Douglas's Tables; this, added to the ash per cent., gives when subtracted from 100, the percentage of water. In the same volume of the *West Indian Bulletin*, p. 167, Mr. R. R. Hall published a number of results of analyses of Barbados vacuum pan molasses in which the water had been determined by Heron's formula and direct drying, and which appeared to show that Heron's formula did not hold good.

Consequent upon the results of Hall, work was undertaken, with a view of ascertaining how far Heron's formula is reliable with regard to molasses from Antigua and St. Kitts. A number of samples was obtained from the sugar crop of 1911 from these islands. On these were determined the specific gravity of a 10-per cent. solution 30°/16·6° by means of a Sprengel tube, and the ash by sulphation and ignition at a low red heat, and subsequent correction by means of the factor 0·95.

The sucrose was found by the Clerget process, using the method described by Watts and Tempany, *J.S.C.I.*, XXVII, p. 191, and the glucose by titration of a 10-per cent. solution against Fehling's solution. The water content was determined by direct drying in a specially devised apparatus which was a modification of that due to Thorne and Jeffers, *J.C.S.I.*, 1898.

In the determination a known volume of a 10-per cent. solution was absorbed upon a tared coil of filter paper and

dried at 98° C. in a slow stream of dry air, under reduced pressure. The refraction index was also determined on each sample.

In all, seven samples were examined in this way, five being muscovado molasses and two vacuum pan molasses.

These results show that the water, as determined by Heron's formula, in all cases agrees closely with the figure obtained by actual drying, the greatest divergence being only 1·8 per cent.

The method gave closer approximation to accuracy than did the refractive index in the case of our own results.

Hall in his paper recommends the use of a factor in calculating the water content, based as the ratio between the total solids other than sugar, as found by analysis, and the apparent total solids other than sugar, obtained from the specific gravity figure.

From our results it appears that such a factor is likely to be useful when the ash content of samples does not vary except within narrow limits, and when the composition of the ash is fairly constant. If these vary widely, however, larger divergences may be looked for.

The Conference adjourned until the next day, Thursday January 25, at 9 o'clock. Before the holding of the morning session, delegates were given an opportunity of visiting the Tram Car system and workshops by kind invitation of the Trinidad Electric Company, and for the purpose, special cars were provided, which left Queen's Park Hotel at 7.10 a.m.

Plant Diseases and Pests, Cocoa-nut, Lime and Fruit, and Rice Industries.

The subjects for the session commencing at 9 o'clock on January 25, were concerned with Plant Diseases and Pests, Cocoa-nut, Lime and Fruit, and Rice Industries. Before the ordinary business was commenced, the Hon. B. Howell Jones (British Guiana) gave notice of a motion, to be brought forward by him at a later session of the Conference, concerning the manner of holding the meetings at future gatherings of the kind. The President appointed a Committee for the purpose of holding preliminary discussions in relation to the appointment of a West Indian Trade Commissioner in Canada, the following being asked to serve: The Hon. B. Howell Jones, the Hon. G. G. A. Wyatt and Mr. J. J. Nunan (British Guiana); Mr. Norman Lamont and Mr. H. Warner (Trinidad); Sir Frederick J. Clarke and Mr. F. A. C. Collymore (Barbados); the Hon. D. S. de Freitas (Grenada); the Hon. J. G. W. Hazell (St. Vincent); Mr G. Barnard (St. Lucia); Mr. F. E. Everington (Dominica); Mr. A. P. Cowley (Antigua); Mr. T. R. Yearwood (St. Kitts); the Hon. J. S. Hollings (Nevis); with Mr. W. N. Sands (St. Vincent) as Secretary. [Ultimately, in consequence of the Conference to be held at Ottawa concerning trade reciprocity between Canada and the West Indies, in March 1912, consideration of matters in connexion with the appointment of a West Indian Trade Commissioner in Canada was postponed.]

The regular business of the session was commenced by the reading of a paper entitled The Use of Entomogenous Fungi on Scale Insects in Barbados, by Mr. J. R. Bovell, I.S.O., Superintendent of Agriculture, Barbados. An abstract follows:—

Attention is drawn first to observations that were made by the late Mr. J. H. Hart, F.L.S., in Trinidad, on fungi attacking scale insects. This early work led to the discovery of the red-headed fungus (*Sphaerostilbe coccophila*) and of the white-headed fungus (*Ophionectria coccicola*) as fungi parasitic on scale insects in the West Indies. At about the same time, Mr. H. Maxwell-Lefroy, M.A., Entomologist to the Imperial Department of Agriculture, reported in papers in the *West Indian Bulletin*, Vol III, pp. 240 and 295, a fungus parasitic on the brown shield scale (*Saissetia hemisphaerica*); this was probably the shield scale fungus (*Cephalosporium lecanii*). Similar observations have been made since, in other West Indian islands.

In August 1909, the author found that the black scale (*Saissetia nigra*) was being attacked by a fungus, in Barbados. Branches bearing the scale and its fungus were tied in scale-infested plants of different kinds, when it was seen to be capable of keeping in check the green scale (*Coccus virdis*), the mango shield scale (*Coccus mangiferae*) and the mealy shield scale (*Pulvinaria pyriformis*). A distribution of material containing parasitized scales was then made to different parts of the island, when it was found that, although the growth of the fungus was checked by succeeding dry weather, when the rains came the artificial infection was generally successful.

In the course of the experiments, the glassy star scale (*Vinsonia stellifera*) was seen to be attacked by *Cladosporium* sp., and the Bourbon Aspidiotus (*Aspidiotus destructor*) by a fungus, possibly *Phoma* sp. It is mentioned incidentally that at the same time a hymenopterous insect and a mite were found parasitizing the glassy star scale, and a mite in the same way on the purple scale (*Lepidosaphes beckii*). Subsequently, attempts have been made to spread the fungi by spraying attacked plants with the spores suspended in water. While the work has been going on, another fungus has been found on the green scale; this is a species of Verticillium, possibly the one called the cinnamon fungus in Florida. Actual observations have shown that this fungus is parasitic in the way indicated, and experiments in which it was cultivated and sprayed on to plants for the control of the green scale have been successful. It has not so far been possible, however, to infect successfully the white fly on Ipomoea with this fungus, although this has been done with a related or identical species in Florida. Experiments are being carried on for the purpose of seeing if it is possible to spread the red-headed fungus in the same way as the Verticillium has been disseminated—by artificial means.

Two fungi have been seen parasitizing the croton bug (*Orthezia praelonga*), but it has not been found possible so far

to control this pest by spraying with the spores of the fungus; this circumstance is probably due to the incidence of dry weather with high winds. Record is made of the fact that a fungus, in addition to the one found last year on the glassy star scale, has been discovered recently, but its identity has not yet been ascertained.

The experience in Barbados, and the work that has been done already in Florida and other places, give the author hope that it will eventually be possible to keep in check most of the insect pests attacking economic and other plants and trees, in Barbados.

After The PRESIDENT had summarized the general principles on which the work described in this paper was based, the Hon. B. HOWELL JONES (British Guiana) asked if there was not a danger that, when the fungi had done their work of destroying the insects, they may take the place of the latter in attacking the plants. In reply, Mr. J. B. RORER stated this is not likely to occur.

The next paper, by Mr. F. W. SOUTH, B.A., Mycologist on the Staff of the Imperial Department of Agriculture, dealt with Further Notes on the Fungus Parasites of Scale Insects of the Lesser Antilles, and included the following matters:—

This paper is a continuation of the details given in the *West Indian Bulletin*, Vol. XI, part 1, and is based on information supplied at monthly intervals from the Windward and Leeward Islands. The fungi dealt with are the four already known, namely; the red-headed fungus (*Sphaerostilbe coccophila*), the white-headed fungus (*Ophionectria coccicola*), the black fungus (*Myriangium Duriaei*), and the shield scale fungus (*Cephalosporium lecanii*). The occurrence of the Aschersonia stage of *Hypochrella oxyspora* on the mango shield scale in Dominica, Antigua and St. Lucia is recorded, as well as of an unidentified Cladosporium on aphids, on a hymenopterous parasite of the glassy star scale (*Vinsonia stellifera*) and possibly on the scale itself in Barbados, and on white fly in St. Vincent; its parasitism has not been established. An unidentified black fungus on the white scale (*Chionaspis citri*) has been seen in Dominica and Antigua on lime trees. In addition, new hosts and new localities are recorded for the previously described species.

Sections of the paper deal with the effectiveness of the fungi, with their periodicity; with the effect of Bengal beans and cover crops; with the artificial encouragement of these parasites, with considerations regarding the use of insecticide sprays; and with some details regarding the fungi themselves. It may be stated that the parasites are to be found throughout the year on scale insects, but they are more in evidence in the rainy season. Except in the islands of Dominica and St. Lucia, their full effect will never be realized until concerted efforts are made to assist their spread.

The PRESIDENT drew attention to the general recognition that exists, of the fact that practically all the fungi mentioned by the author of the paper are instrumental in maintaining the health of citrus and other trees, especially in

Dominica, where the natural conditions are suited to them; they were also being employed to a considerable extent for the control of scale insects in Grenada. As regards this island, Mr. G. G. AUCHINLECK, the Superintendent of Agriculture, then gave special particulars of the efficiency of the parasitic fungi that had come under his notice, the most important in its effect being the shield scale fungus (*Cephalosporium lecanii*), and further afforded interesting particulars of the cheapness of the control, by means of parasitic fungi, of scale insects that attract black blight. Emphasis was also laid upon the practical importance of the results and adoption of these methods, in a few remarks from The PRESIDENT.

Mr. H. A. BALLOU (Entomologist to the Imperial Department of Agriculture), in reply to Mr. J. R. BOVELL (Barbados) dealt with the commercial developments that had taken place in Florida, in connexion with the matter; here, the important consideration was to keep the white fly in check which attracts the black blight that makes it necessary to scrape the oranges and thus reduce their keeping qualities. In that State, the control of fungi was effective where they are plentiful, but where the spores were sprayed on to the trees the effect was seen six or eight weeks earlier than where the control is entirely natural.

In closing the discussion, The PRESIDENT remarked that the work described was particularly interesting, because (he thought) it was the first occasion on which any extensive allusion had been made to the use of this method of dealing with scale insects, at Conferences of the kind; it marked a new departure and new lines of activity, in the West Indies.

A Report on the Occurrence and Prevalence of Insect Pests and Fungus Diseases in the Windward and Leeward Islands, 1910-11, by H. A. BALLOU, M.Sc., Entomologist, and F. W. SOUTH, B.A., Mycologist, on the Staff of the Imperial Department of Agriculture, formed the subject of the next paper, which is abstracted as follows:—

A report on the prevalence of insect pests and fungus diseases in the West Indies for the year 1909-10 was published in the *West Indian Bulletin*, Vol. XI, pp. 73-106. This report covered the period from April 1909 to June 1910. In the present report two periods are covered, one, referred to as period A, extends from July 1910 to March 1911, and the other, referred to as period B, extends from April to December 1911.

The information presented in this report has been accumulated in the same manner as before; that is, blank forms have been submitted to the Agricultural Officers in each of the islands of the Windward and Leeward groups, and these have been filled in and returned. It should be mentioned, however, that for Grenada and St. Lucia returns are available only for period B. In these abstracts, items of special interest only are presented, such as unusual occurrence or non-occurrence of pests or diseases.

In the report itself, which will be published later in the *West Indian Bulletin*, a more complete account will be given.

The table which is distributed for the use of the members of the Conference serves to show where pests and diseases have occurred in each of the periods under review.

INSECT PESTS. The weevil borer of the sugar-cane occurred in unusual numbers, in one field of plant canes in St. Kitts, in period A. In period B, a renewed outbreak of termites was noted in another field, on the same estate as was referred to in the report for 1909-10 (*West Indian Bulletin*, Vol. XI, p. 86). This was accompanied by the presence of the weevil borer in large numbers. In connexion with cotton pests, the following points may be noted: the cotton worm was comparatively scarce during period A, except in Montserrat and Antigua, and it was extremely in abundance during the period B throughout the Leeward Islands. Cotton stainers were injurious in Nevis and the Virgin Islands during period A, and in Montserrat during period B. In St. Kitts, where this pest has been abundant in the past, it has progressively decreased until in period B there is no record of its occurrence.

The first authentic record of the flower-bud maggot in any island other than Antigua is in Montserrat towards the end of period B. The leaf-blister mite in period B has been more abundant in Montserrat and Nevis than it has been for several years past. Cacao thrips caused considerable damage on certain estates in St. Vincent and Grenada, in period B. Scale insects were as abundant, as usual, in the majority of the islands, on lime trees, except that in Dominica in the two periods in which the weather was normal they were efficiently controlled by their natural enemies. The sweet potato crop in Antigua was unusually free from attacks of scarabee during these two periods. Green dressing crops were seriously attacked by a caterpillar in Montserrat in period A, and in Dominica by a red spider during period B. In St. Kitts the horse bean (*Canavalia ensiformis*) has been adopted for planting on account of its apparent immunity from the attacks of the caterpillars that severely damage woolly pyrol and the velvet bean. Under the heading Miscellaneous Notes at the end of the paper, the occurrence of certain insects of minor importance is noted. These are not yet present in sufficient numbers to cause damage, but are under observation.

FUNGUS DISEASES. This paper follows directly on that dealing with insect pests. The information has been obtained from the same sources, and is treated in the same manner in this abstract. In Antigua, where root disease of the sugar-cane is very abundant, more attention was paid to it during these two periods than formerly. The drought during period B emphasized its presence in Antigua and St. Kitts; in this latter island the seedling cane B. 208 was apparently somewhat susceptible to attack. Instances of a disease that was almost certainly the true red rot, due to *Colletotrichum falcatum*, occurred in St. Lucia in period B.

The bacterial boll disease of cotton was prevalent in St. Vincent in period B, as the result of a wet season. This and the associated angular leaf spot and black arm would appear, from the notes submitted from the other islands, to be far more strongly developed in damp than in dry situations. The West

Indian leaf mildew was abundant in both periods, in St. Vincent, and in period A, in Montserrat, where one field became leafless, but still yielded a good crop. In connexion with root disease of cacao, it would seem that the form found in Grenada may not be the same as the black root disease found in St. Lucia and Dominica. Generally speaking, the root diseases of cacao appear to be under reasonable control, partly owing to the increasing recognition of the importance of sanitation on cacao estates.

It may be noted that, as the result of recent investigation, the root diseases of limes have been found to be due to several causes. The black root disease, common to several host plants including cacao, limes and Castilloa, and the red rot disease, are mainly of sporadic occurrence on newly cleared estates, or near forest.

The leaf spot disease of ground nuts, so seriously prevalent on the experiment plots in Dominica in 1909, was absent in period A. Rust of this crop formed the subject of some experiments with Bordeaux mixture in Montserrat which would tend to show that it can be controlled by spraying: at the same time the disease does not appear to affect the yield to any great extent.

The root disease of Indian corn has decreased noticeably in Antigua and St. Kitts during these two periods. A section dealing with the climatic conditions prevailing in each island in these periods has been added at the end of the paper. This is of interest, since these conditions often affect the severity of attacks of pests and diseases.

In the discussion which followed, Mr. J. R. Bovell (Barbados) was informed by Mr. J. C. Moore (St. Lucia) that the variety of cane mentioned by Mr. South as having been attacked by the true red rot in St. Lucia was thought to be the Bourbon. In reply to Mr. Norman Lamont (Trinidad), Mr. Ballou stated that very little had been done in the artificial control of cotton stainers, and there was no explanation, so far, to account for the sudden disappearances of the pest that took place. In regard to the great decrease in number of this pest in St. Kitts, Mr. F. R. Shepherd (St. Kitts) attributed the circumstance to early planting and removal of the crop; Mr. P. L. Guppy (Trinidad) also referred to the disappearance of the cotton stainers in some years, in Tobago, stating that the circumstance was unaccountable there. Mr. W. C. Fishlock (Virgin Islands), who described the behaviour of the pest in the Virgin Islands and asked for an effective means of control, was referred by Mr. P. L. Guppy to Bulletin No. 6 of the Trinidad Department of Agriculture. The Hon. J. S. Hollings (Nevis) and Mr. H. A. Tempany (Antigua) also gave an account of recent experience with the cotton stainer in the islands which they represented.

Mr. F. W. Urich (Trinidad) desired further information concerning the outbreak of termites, among sugar-canes, accompanied by the weevil borer, which had been described by Mr. Ballou from St. Kitts, asking if the latter pest followed the former. Mr. Ballou gave evidence to indicate that the termites had appeared first; though there had been no opportunity for deciding if outbreaks of termites were followed by

attacks of the weevil borer. In relation to the same matter, Mr. F. R. SHEPHERD said that, in most instances, the canes attacked by termites, were subsequently infested by weevil borer. In relation to the subject, Mr. J. R. BOVELL gave it as his experience that root fungus in the sugar-cane was generally followed by attacks of the root borer.

This discussion was succeeded by a paper by Mr. J. B. RORER, A.B., M.A., Mycologist to the Trinidad Board of Agriculture, treating of The Bud Rot of the Cocoa-nut Palm, which brought forward the following points:—

Bud rot is doubtless the most serious disease, of parasitic origin, of the cocoa-nut palm. It has long been known in the West Indies, but has attracted much attention recently on account of the increased value of cocoa-nut properties and the fact that many estates in some places, notably Cuba, have been ruined by this disease.

Bud rot is evidently of bacterial origin, and the recent work of Johnston shows that it is caused by *Bacillus coli*, or a very closely related form. The disease may gain entrance to the tree at or near the bases of any of the leaves from the youngest to the oldest, of the flower stalks, or through that part of the stem just below the crown. When once within the tissues of the tree its course may be very rapid or quite slow, depending upon a number of conditions which cannot be considered here. The appearance of trees in the early stages of disease varies according to the point of first attack, as may be seen from the photographs that are shown, but finally the crown falls and the sound stem is left standing in the air.

Though both diseases may be present in the same tree, bud rot must not be confused with the so-called Trinidad root disease, which is always characterized by diseased roots and a red ring of tissue in the stem, and seems to be due to physiological causes rather than an organic parasite.

Bud rot is prevalent in Trinidad, and measures are being taken to prevent its spread. So far, sanitation alone has been used, but the results have been successful. From November 30, 1909, until February 1911, one of the Agricultural Inspectors visited all the districts of the island where cocoa-nuts are grown, and supervised the destruction of all dead and dying cocoa-nut trees. About 18,000 trees have been destroyed. In all cases where bud rot was evident all the diseased tissues were placed in a trench, covered with lime, and buried. The trunks of the trees were cut into chunks about 4 feet long, stacked around the stump with the dried leaves and trash so that they could be burned or at least charred, after drying in the sun for a time. Now that this preliminary cleaning up has been done, it is hoped that the new Plant Protection Ordinance will be enforced in regard to this disease, so that as soon as a tree becomes infected it must be immediately destroyed.

Spraying the crowns of the trees in order to protect them from infection has not yet been tried on a large scale, on account of the lack of a proper machine for this work, but there can be no doubt that the rapid spread of the disease could be checked in this way.

Specimens of palms affected by both bud rot and root disease, and a number of photographs, accompany the paper.

In reply to a question by the Hon. B. HOWELL JONES (British Guiana) as to the discrimination between different varieties of cocoa-nuts in the West Indies, Mr. W. G. FREEMAN (Trinidad) did not think that any definite attention was being paid, in Trinidad, to the subject at the time, though it was recognized that different varieties of cocoa-nuts are imported, one of them being a distinct form from Venezuela.

The following is a synopsis of a paper entitled Cocoa-nut Palm Insects in Trinidad, by F. W. URICH, Entomologist to the Board of Agriculture, Trinidad, which succeeded the discussion:—

The matters dealt with in this paper are briefly as follows:—

(1) Beetles boring in the stem.
  The palm weevil—*Rhynchophorus palmarum.*
  The bearded weevil—*Rhina barbirotris.*
  The small weevil borers—*Metamasius hemipterus* and allied species.
  The Ambrosia beetles.

Relation of beetle attacks to health of trees. Dangers of 'firing' trees. Control.

(2) Insects affecting the leaves.
  The cocoa-nut butterfly—*Brassolis sophorae.*
  Scale insects. Relations of ants to scale insects.
  The spraying of tall trees.

(3) Beetles affecting young plants.
  The rhinoceros beetle—*Strategus anachoreta.*

(4) Relations of insects to bud rot.

On the completion of this paper, The PRESIDENT invited Mr. ALLEYNE LEECHMAN, F.C.S., Science Lecturer, British Guiana, to give a description of a specimen of the fruit of the Coco-de-mer exhibited at the Conference, from the Botanic Gardens in that Colony. During the description, photographs were shown of the plants at the Gardens, and the interesting fact was mentioned that, as far as is known, the specimen shown is the first example of the fruit produced in the Western world. In regard to the latter circumstance, however, the Hon. J. S. HOLLINGS seemed to think that fruit of the Coco-de-mer had been produced in St. Kitts. The circumstance of the discussion of a new plant was used by The PRESIDENT to draw the attention of the Conference to a specimen of a new variety of Bougainvillea, introduced recently into Trinidad from Carthagena, which, he said, was well worth distributing and growing in the West Indies.

These matters were followed by the reading of notes by Mr. H. A. BALLOU, M.Sc., Entomologist to the Imperial Department of Agriculture, on Scale Insects and Their Insect Parasites, which has been abstracted as follows:—

This paper presents figures to show the abundance of parasitic insects in Grenada and St. Vincent, as revealed in the

reports on the collection of parasitic Hymenoptera in those islands. The material was collected for the Royal Society and a Committee of the Royal Commission, and studied by specialists at Washington, D.C., U.S.A.

Mention is made of a few striking instances of the control of pests by natural enemies, in the United States and in the West Indies. The cotton cushion scale (*Icerya purchasi*) and the lady-bird (*Vedalia cardinalis*), the black scale (*Saissetia oleae*) and its parasite (*Scutellista cyanea*) in California, and the citrus white fly and fungus parasites in Florida are the examples cited from the United States. From the West Indies the following are mentioned, among others: scale insects and their natural enemies in Dominica, the black scale of cotton (*Saissetia nigra*) and the parasite *Zalophothrix mirum*, and the cotton worm and its natural enemies.

Reference is made to the effort being put forth in other parts of the world in the search for, and attempts to utilize, enemies of serious pests, at great expense.

An account is given of the plan of an investigation to accumulate knowledge regarding scale insect pests and their parasites in the West Indies. The results show that several species of parasites have been identified from specimens bred from scale insects: some of these were new to science.

Tables show the parasites, with hosts and distribution, so far as these are known, with similar information regarding other natural enemies. An account of *Zalophothrix mirum* includes points of interest in its life-history.

With reference to the practical utilization of native parasites in the control of pests, information is given as to the methods which may be employed in introducing these beneficial insects into localities where it is desired to establish them.

The notes conclude with a brief account of the control of the San José scale in California by a native parasite (*Aphelinus fuscipennis*). This insect and another, *Aspidiotiphagus citrinus*, which is an efficient check on San José scale in Japan, occur in the West Indies.

On the completion of Mr. Ballou's paper, the author, in reply to Mr. J. R. BOVELL (Barbados), stated that material showing insect parasites on Aphis had been received at the Head Office of the Imperial Department of Agriculture, but that they had not been studied, nor was there the literature at hand to enable a definite opinion to be given as to the group to which they belong. Mr. BOVELL mentioned an instance of a large parasitization of Aphis on the melon.

Professor J. B. HARRISON gave an address on Experiments with Rice in British Guiana, in which the following were the chief matters brought forward:—

In view of the fact that there are at present 40,000 acres under rice cultivation in British Guiana, it had been thought by the Department of Agriculture that, although it was known that the variety of rice indigenous to the Colony is of excellent quality, trials should be made with kinds from other countries, and with this object 230 to 250 varieties had been imported

from different parts of the world. These had been grown in the way that had been adopted for the sugar-cane experiments, and so far it had been found that only three of them are superior in quality to the creole rice, while this superiority does not amount to an increase of yield of more than 10 per cent. Attempts had been made at artificial hybridization of the rices, but as with the sugar-cane the difficulty of variation had been encountered. The present method of working was to grow the plants in plots having an area of 2 or 3 acres, and to choose and grow separately the produce of any among them that show marked signs of variation from the bulk. It was not until last year that the work had been conducted long enough to give definite results. An example was given of an excellent variety called No. 75, which yielded 30·5 bags (of 120 ℔.) of paddy per acre; variants from this had given from 40 to 49 bags per acre. This suggested the usefulness of the employment of such variants for obtaining improved kinds of rice, but it was not yet known if the special characters are fixed. Other examples had shown the efficacy of the system, and the results from one of these were quoted by Professor Harrison.

It is intended to cross-fertilize the best variants that have been obtained. In any case time is required for obtaining definite results, for it is already ten years since the experiments were commenced.

The PRESIDENT emphasized the importance of the results that had been obtained by Professor Harrison, laying stress on the necessity for caution in the first steps of an investigation of the kind described, even if this caution required in the laying of the foundation of the work brought it about that a long time had to be spent in preliminary experimentation.

The following points were brought out in a paper by Mr. J. B. RORER (Trinidad) on Some Fruit Diseases :—

The fruit industry is now assuming such importance in the West Indian Islands that attention must be called to some of the fungus disease of these products.

During the past season many thousands of mangoes and avocados have been shipped from Trinidad to New York and England, but often the fruit has arrived in such poor condition that it was unsaleable and the whole shipment was lost. A great part of the deterioration of these fruits in transit is due to the growth of parasitic fungi. Both the mango and the avocado are very subject to the disease known as anthracnose. In both cases the causative fungi attack not only the fruits, in all stages of development, but the leaves also, and, in the case of the mango at least, the flower and flower stalks. Both diseases are very easily controlled by spraying with Bordeaux mixture, but the work must be very thoroughly done and started in good season; that is, while the trees are in bloom. Both mangoes and avocados from trees which have been thoroughly sprayed stand shipment much better than similar fruit from unsprayed trees.

Bananas, in Trinidad at least, are so susceptible to diseases which as yet cannot be adequately controlled, that it would

not be advisable to plant large areas in this crop. Climatic conditions, too, are against it.

The two most prevalent troubles are the Panama disease, which is especially severe on the Gros Michel variety, and the bacterial disease which attacks plantains of all kinds, the dwarf and the red banana.

Photographs and specimens show the character of these various fruit diseases.

After this paper had been read, Mr. W. G. FREEMAN (Trinidad), replying to Mr. J. R. BOVELL (Barbados), stated that the Governor bananas were shipped uncrated from Trinidad.

A paper entitled Experiments in Lime Juice Concentration, by the Hon. J. C. MACINTYRE (Dominica), was then read by Mr. H. A. Tempany (Antigua); in this the following matters were chiefly dealt with:—

These experiments were carried out for the purpose of ascertaining the loss of acid in lime juice at different concentrations, in order that a conclusion may be formed as to the advisability of concentrating lime juice in the ordinary way, or after incurring the expense due to the purchase of plant for steam concentration. The earlier experiments showed considerable variation in results, because of (1) unequal firing arising from bad fuel; (2) the unsatisfactory method of measuring the concentrated juice; and (3) to the fact that, owing to the pressure of crop work, it was not possible to allow the juice thoroughly to cool before being gauged. Besides the ordinary boiling house equipment, the plant employed consisted of: three copper taches, two of 150 gallons each, and one of 250 gallons; a package of 240 gallons for measuring the distilled juice employed in the experiments; a package of 300 gallons capacity, fitted with a hook gauge, for measuring the concentrated juice. A gauge of this kind was only used in the later experiments, and on account of the increased accuracy obtained by its employment, a detailed description of it is given.

The results of the experiments are expressed in a curve which correlates the degree of concentration with the loss of acid, the citrometer readings being marked on the curve. In this it is shown that the degree of economical concentration is about 9 to 1, corresponding to 97·6 oz. of acid per gallon with a loss of 9·3 per cent. On the citrometer this would be represented by 54, at boiling point. In all cases the strike was taken from the copper furthest from the fire, and the author emphasizes the importance of employing this measure, in preventing the additional loss that occurs when striking is done from the copper immediately over the fire. It is stated that the latter system probably no longer obtains on any estates in Dominica.

Figures are given to show that at a 7 to 1 concentration, 1,000 gallons of juice containing 12 oz. of acid per gallon would, on a basis of £18 10s. per pipe, represent a net value of £21 3s. 4*d*. On the same basis, 1,000 gallons of juice at:—

8 to 1	concentration	would	represent	£21 12*s*. 4*d*.
9 ,, 1	,,	,,	,,	£21 14*s*. 7*d*.
10 ,, 1	,,	,,	,,	£21 12*s*. 9*d*.

The results were checked as to their correctness by comparing the value as estimated with the prices obtained for the produce in London. The difference between the two, for the entire crop, is less than one per cent.

The figures show that the differences in value between concentration at 8 to 1 and at 9 to 1, and between those of 9 to 1 and 10 to 1 amount to less than ½-per cent—a difference well within the limit of variation in losses over open fires. The precise point of concentration does not matter much, between the limits of 8 to 1 and 10 to 1; though the adoption of the lower degree of concentration would result in some advantage in fuel and labour. The proportion of loss of acid increases very rapidly above the latter concentration. The conclusion is reached that the total loss of acid, under conditions of careful supervision and of most economical concentration is about 13 per cent.—an amount that, on a crop of 10,000 barrels of limes (say, 85,000 gallons) would be about £240, with the juice at £18 10*s.* per pipe. It is authoritatively considered that the loss of acid in steam concentration in jacketed pans is about 3 per cent. at 9 to 1: to this must be added loss from filters or skimmings, that from the latter probably being the greater. Further, in relation to citrate manufacture, the advantages of this over concentration are: (1) a minimum of loss in manufacture; (2) the higher price usually, but not always, obtained for the product; (3) the greater rapidity of working; (4) the saving of losses during carriage; (5) a saving on the cost of packages, against which however must be placed the cost of chalk and the somewhat greater cost of manufacture when the work is done on a small scale.

Further attention was given to the subject of lime juice preparation in a paper presenting Investigations on the Extraction of Juice by Milling, by Mr. H. A. TEMPANY, B. Sc., F.I.C., F.C.S., Government Analyst, and Mr. V. M. WEIL, B.Sc., Assistant Government Analyst. Antigua. This has been abstracted as follows :—

The investigations were inaugurated with the idea of endeavouring to devise some simple method for controlling the work of lime mills.

The underlying idea was that the principle involved in the milling of limes is essentially similar to that involved in the case of sugar-canes.

Ideas as to the efficacy of lime mills at present are ill-defined. The usual expression for the mill work is in terms of gallons of juice expressed per barrel of limes. This is a very haphazard method, and does not provide a standard for measuring the quantity of limes from which the juice is expressed; moreover it it is not unlikely that the receptacles in which the juice is received are often considerably in error in the measurements which they record.

The analysis of megass from cane mills sheds valuable light on the quality of the mill work done, and this has been found to be especially useful when the composition of expressed juice is employed to calculate the factor: normal juice lost per 100 fibre.

There does not seem to be any reason why equally useful light might not be shed on the work of lime mills by the analysis of expressed skins.

With the object of devising such a method, it appeared that a useful purpose would be served by obtaining some information as to the juice content of limes and the manner in which it varies according to the localities in which the limes were grown.

Accordingly samples of limes were obtained from two estates in Antigua, three in Montserrat and five in Dominica.

On each of these samples was determined the average weight and volume of one fruit. Ten average fruits were then weighed, cut in half and gently squeezed by a hand press, the juice being collected in a tared beaker, and weighed. On the juice the acidity in terms of citric acid and specific gravity, and on the skins the moisture and percentage acidity in terms of citric acid, were determined. From these factors the actual percentage of juice in each sample was calculated, the formula used being

$$\text{juice content} = x + (100 - x)\frac{a}{b}$$

x = percentage of juice extracted.
a = acid per cent. by weight of skins.
b = acid per cent. by weight of juice.

Tne results are given in a table.

The method of determining the acidity of the skins is a modification of Prinsen Geerligs's beaker method for determining sucrose in megass. Comparison of results obtained by this method with determinations obtained by extraction in a Soxhlet apparatus yielded closely comparable results.

On examining the results, it appears that while the weight and volume of a single fruit, and the acidity of the juice, vary largely according to the locality in which the fruit is grown, the percentage of juice contained by the fruit varies relatively little, amounting approximately to 62 per cent. of the total weight of the fruit. This is somewhat unexpected, but the results obtained consistently indicate this.

The percentage of juice expressed varied considerably in different samples; in the results quoted, however, this appears to be owing to the fact that the small fruits did not fit the squeezer as well as those of larger size.

As a result, it appeared that a feasible plan for controlling mill work would be to ascertain by analysis the amount of juice lost on a standard weight of lime skins. For practical purposes, these units would appear to be capable of convenient expression in terms of gallons of juice lost per 100 lb. of lime skins.

To test the practical applicability of this method of control, tests were performed on a number of mills in Antigua, Dominica and Montserrat. The method employed was to take a sample of pressed skins as they left the mill, and a sample of the juice running from the mill at the same time. On these samples the acidity of the juice and of the pressed skins is determined,

and the results are expressed in terms of gallons of juice lost per 100 ℔.

This is easily calculated by the formula :—

$$\frac{\text{acidity of skins per cent.}}{\text{acidity of juice in ℔. per gallon}}$$

From a large number of determinations, it was found that this figure ranged from 1·8 to 4·3, and averaged 2·6. In the majority of cases the results did not depart very far from the mean value, ranging between 3·0 and 2·4.

In the case of the mill giving the low result of 1·8 above alluded to, it may be said that this is of modern pressure regulating type fitted for grinding canes, and it seems reasonable to regard the work done by it as a standard, as far as the results available up to the present are concerned. If this is the case, it appears from the results so far obtained that under average conditions close on 1 gallon of recoverable juice is lost per 1¼ barrels of limes, assuming that 1 barrrel of limes yields 80 ℔. of skins.

It seems probable that when raw juice is being manufactured for the purpose of making lime juice cordial, very high pressures are undesirable, owing to the amount of pectic matter likely to be introduced into the juice in consequence, but when concentrated juice is being manufactured, the condition of affairs is different, and it is suggested that careful attention to the milling of limes on the lines indicated is likely to be productive of appreciable increases in output.

For the performance of a number of tests on Dominica lime mills, we are indebted to Mr. G. A. Jones, Assistant Curator, Dominica.

The last paper to be taken at this session was Some Root Diseases of Permanent Crops in the West Indies, by Mr F. W. South, B.A., Mycologist on the Staff of the Imperial Department of Agriculture. The following are the main points brought out :—

The root diseases dealt with are discussed under five popular names ; though in some cases it is uncertain if each name includes only one, or more than one, causative fungus.

(1) White root disease is characterized by the occurrence of a white mycelium, generally found in star-like masses between the wood and the bark. There is reason to believe that it belongs in the different cases to a fungus or fungi of the group Hymenomycetes—probably to the families Agaricaceae or Polyporaceae. Under this head are included :

(a) A disease found by Barber in Dominica, in 1892, on cacao, Liberian coffee, mangoes, oranges, pois-doux, bread-fruit, eddoes, sugar-cane, *Cassia Fistula*, cassava and bitter orange.

(b) A disease found by Howard in 1900, and re-described by Auchinleck in 1910, in Grenada, on cacao, nutmegs, coffee, bread-fruit, bananas and possibly mangoes.

(c) A disease found by Earle in Jamaica, in 1902, on logwood and cassava.

(d) A disease described by Stockdale in 1908 as occurring in Grenada, St. Lucia and Dominica on cacao, pois-doux, bread-fruit, bread nut, mango, pomme rose, and avocado pear.

There is no definite proof that all these diseases are due to the same fungus, as no fructifications have been found; possibly several species are involved.

(2) Thyridaria root rot is due to *Thyridaria tarda*, better known as *Diplodia cacaoicola*. It is mainly parasitic on the roots of cacao growing in ill-drained bottom lands. No external symptoms appear on the roots, but the wood is discoloured grey and the bark is darkened, while pustules containing the pycnidia may be found on the bark of the older roots.

(3) Black root disease due to a species of Rosellinia, near *R. bunodes*, has been found on cacao, limes, pois-doux, mahoe cochon, Hibiscus and Acalypha, in Dominica. It occurs sporadically on estates in the interior. A disease with similar characters appeared on cacao, limes, Castilloa, immortel and pigeon pea in St. Lucia; on cacao in St. Vincent, where there is also a suspicion that it causes burning of arrowroot; and on Castilloa in Grenada.

It is distinguished by the occurrence of a dark-brown mycelium on the surface of the diseased roots, a dark olive-green mycelium with a grey advancing margin round the base of the stem, and the development upon this of numerous crowded bristle-like conidiophores, which in the mass produce an appearance like the pile of a carpet. These only form on trees that have just died, or are nearly dead. They give rise to numerous colourless conidia. When a tree has been dead for some time, perithecia arise in clusters on the above-ground mycelium.

(4) Red root disease, due to a species of Sphaerostilbe possibly undescribed, occurs sporadically on limes in Dominica and will probably be found elsewhere. It may be distinguished by the occurrence, in the decaying bark of the roots and collar, of a very thin, flat, red plate of fungus mycelium and of narrow, long, red strands on the surface of the bark of younger roots. Round the collar, Stilbum fructifications form. These sometimes occur in the angles of the main roots below ground. Perithecia have only been found on one occasion, and then only a few occurred.

(5) Root canker is found on limes in Montserrat, and probably in Antigua. Trees affected by it die slowly and exhibit a considerable amount of dead wood at the top or on one side. A constant character is the presence of very few fibrous roots in the soil round badly diseased trees; there is no very obvious mycelium present, though in advanced cases the bark is decayed on several of the roots and the wood may be dry and dead beneath.

Open canker wounds surrounded by callus are formed on the roots in cases where the tree has been able to check the advance of the disease. The cause of it is uncertain, and is complicated by the presence of scale insects on the branches of some of the trees exhibiting it, though it is sometimes associated

with the production of the brackets of *Fomes lucidus* in considerable numbers.

The occurrence of other diseases of a similar nature to these, in other countries, is discussed in this paper, while sources of infection and remedial measures, as well as the above-ground symptoms are also dealt with.

Several other papers intended for this session had to be taken as read, for want of time to deal with them. These are mentioned, with their abstracts, below.

Notes on Expressed and Distilled West Indian Lime Oils, by H. A. TEMPANY, B.Sc., F.I.C., F.C.S., Superintendent of Agriculture, and N. GREENHALGH, B.Sc., Agricultural and Science Master, Antigua :—

The lime, like the fruits of other members of the Citrus group, contains essential oil vacuoles situated immediately beneath the outer rind, or skin. Two classes of lime oils are at present known to commerce :—

(1) The hand expressed oil, or otto of limes.

(2) The distilled oil.

Hand-expressed oil is obtained by rapidly rotating the fruit round the interior of a copper bowl, termed an écuelle pan, the inner surface of which is covered with projecting brass points.

The distilled oil, on the other hand, is obtained by performing the first stage in the manufacture of concentrated lime juice, in a copper still, and condensing the distillation product; the steam passing over carries with it the more volatile portion of the oil, which is collected in a form of Florentine flask.

It may be pointed out that both the distilled and the hand-pressed product have their origin in the rind.

The comparative paucity of information concerning the characteristics, chemical and physical, of both classes of lime oil prompted the collection of a number of samples of both oils from Dominica and Monsterrat for purposes of examination in the Government Laboratory for the Leeward Islands.

Data concerning the characteristics of lime oils are given, abstracted from Gildmeister and Hoffman's work The Volatile Oils, Schimmel's Semi-Annual Reports and Allen's Commercial Organic Analysis.

HAND-EXPRESSED OIL. 'The oil is of a golden colour, and is hardly distinguishable from a good lemon oil by its odour. Its most important constituent is citral. It contains also a paraffin, limonene, methyl anthranilate, and 10 to 18 per cent. of non-volatile residue. The oil gives a cloudy solution in 4 to 10 volumes of 90 per cent. alcohol with separation of wax.'

Density at 15° C. 0·878 to 0·901
Rotation in a 100 mm. tube 32° 50′ to 40°
Refractive index 1·482 to 1·686
Acid number up to 8·0
Ester number 18 to 30.

DISTILLED OIL. The oil has an unpleasant odour like turpentine or pine tar oil, and no longer reminds of citral. Probably the aldehyde is completely destroyed by the boiling of the acid liquid. The oil boils between 173°C. and 220°C. Residue on evaporation 3 per cent.

Density at 15°C. 0·865 to 0·868
Rotation in 100 mm. tube 38°52′ to 46°36′.

For the purpose of this investigation seven samples of expressed oil and three samples of distilled oil were obtained from Dominica, Montserrat, and Antigua.

On each of the samples were determined :—

1. The sp. gr. at 30°C.
2. The optical rotation in a 100 mm, tube.
3. The refractive index at 32°C.
4. The citral by Burgess's and Child's method.
5. The acid number by titration.

The main results are summarized as follows : —

HAND-EXPRESSED OIL.

Specific gravity	0·8659	to	0·8859
Optical rotation	31·38°	to	34·89°
Refractive index	1·4789	to	1·4836
Acid number	1·35	to	2·8
Citral content	2·2	to	6·6 per cent.

DISTILLED OIL.

Specific gravity	0·8540	to	0·8858
Optical rotation	33·09°	to	34·89°
Refractive index	1·4702	to	1·4713
Acid number	0·76	to	1·3
Citral content	1·2	to	2·0

With regard to the hand-expressed oil the results show a somewhat wider divergence between the characters of the different samples than that indicated by figures given by the various authorities already quoted, although they are in general agreement with them. The citral content and acid numbers vary markedly in the different samples. It is interesting to note that a fairly close correlation appears to exist between the two figures.

On the whole, the citral content of the hand-expressed oil is considerably lower than is the case with lemon oils, which are stated to contain 7 to 10 per cent. of that constituent.

From the results it appears that there is some relation between the physical constants, the citral content, and acid number.

To obtain a certain amount of information regarding the different bodies of which the oil is made up, samples of distilled oil, hand-expressed oil, and hand-expressed oil which had been subjected to steam distillation, were fractionally distilled, 100 c.c. being taken for each distillation.

From the results it appears that during the process of distillation with steam (the conditions under which ordinary distilled oil is obtained being practically those of a steam distillation), a certain proportion of the lower and higher

boiling constituents are removed. The blue fluorescence due to the presence of a crystalline substance characteristic of the higher fractions of the expressed oil is entirely absent in those of the distilled oils. This substance is in all probability the methyl anthranilate which is known to exist in lime oil, to the methyl ester of which J. Parry ascribes the blue fluorescence of mandarin orange oil. This is probably removed during steam distillation.

In both expressed and distilled oils the largest fraction is obtained between 170° C., and 180° C., and almost certainly consists largely of limonene or closely related bodies.

Expressed oils on standing generally deposit a pale yellow crystalline substance known as limettin; this, according to Tilden, is dimethoxy-coumarin; distilled oils on the other hand do not deposit this body. It seems therefore possible that distillation with steam may effect the removal of that constituent of expressed oils which may possibly be converted into limettin by slow oxidation.

The proportion of citral is also much less in distilled oils than in expressed oils, owing probably to chemical changes brought about during the distillation.

These, then, are some of the possible causes of the marked differences between the two classes of oil.

At present, however, our knowledge of the constituents of the oils is too meagre for us to be able to explain fully the nature of the changes taking place during the steam distillation of lime oil.

The Lime Industry of Antigua, by Mr. H. A. TEMPANY, B.Sc., and Mr. T. JACKSON, Curator, Botanic Station, Antigua. This is reproduced in full; it is too short to necessitate an abstract:—

Limes have been cultivated to some small extent for many years in Antigua, but until the last few years the total trade in the products of the industry has been but small.

During the past few years, however, interest in the crop has very considerably increased and large extensions of the area planted have been made.

At the present time there are approximately 500 acres under the crop, and of this probably not more than 200 acres are bearing.

The value of the exports of lime products during the past nine years has increased from £267 in 1900 to £2,269 in 1909-10.

A point of some significance, which indicates the amount of interest now being taken in this form of cultivation, is that during the past year, 1911, the number of lime plants distributed from the Botanic Station exceeded the total distribution during the entire period 1901-9.

The areas in Antigua which may be regarded as the most suitable for growing limes are situated in the south of the island. Here the soils are of volcanic origin and light and deep, and the rainfall is more abundant than in other districts. It

is in this part of the island that the greater part of the planting is now being carried on; though areas have also been established on the limestone soils in the northern and eastern parts of the island, where the rainfall is much lower.

While the condition obtaining cannot be regarded as ideally suited to lime-growing, nevertheless the success so far attained by the older planting prompts the hope that the prospects may be favourable for these more recently established.

So far, no very serious attacks by pests or diseases have befallen the industry. Scale insects are everywhere prevalent but they appear to be held in check to a considerable extent by natural enemies.

The Acid Content of Lime Fruits, by Mr. G. A. JONES, Assistant Curator, Dominica:—

Reference is made to a report of former work in this connexion, in the *Agricultural News*, Vol. IX, p. 260. The investigations described in the present paper tend to show: (1) that the acidity of the fruits may decrease, as regards different localities, with increase of rainfall; (2) it may be that, when a certain limit is reached, provided that the soil is well drained and of an open texture, the rainfall does not affect further the acid content; (3) generally speaking, the greater the rainfall the larger the number of fruits produced, and the larger their size; (4) under similar conditions, the acidity of large fruits is smaller than that of those less in size; (5) plants on open and pervious soils are likely to produce more acid fruits than those on retentive soils, even when the rainfall is greater on the former soils; (6) lime trees, as they attain maturity, produce fruits having a higher acid content; (7) the spineless lime usually bears fruits that are more acid than those from the ordinary kind, though this superiority seems to be lost in the hills or in the Windward coast, so that the greater acidity of the fruit of the former appears to be dependent on environment rather than to be a fixed character; (8) increased acidity seems to be a fixed character, as far as individual trees are concerned, and this suggests that chemical selection may be usefully employed. After a presentation of these matters has been given, the paper proceeds to discuss the economic importance of the investigations in the following way: 'A pipe of citric acid is now quoted at £18 10*s.*; 1 oz. of citric acid is therefore worth slightly over 0·64 pence, on the London market. In Dominica, to-day, with the London prices at £18 10*s.* per pipe, 5*d.* per gallon is paid for raw lime juice containing 12·4 oz. of citric acid to the gallon. Packages are supplied, and the juice will be removed from the estate at the price quoted. At 5*d.* per gallon of 12·4 oz. citric acid, 1 oz. of citric acid is worth 0·4 pence. If, therefore, for some cause or other one estate produces raw lime juice containing, say, 1 oz. of citric acid per gallon more than another one, and assuming that both estates give a yield of 100 barrels of limes to the acre per annum and that both estates extract 8 gallons of juice per barrel, the first estate produces 800 oz. of citric acid per acre more than the other. Valued at London prices, this increase is worth £2 2*s.* 8*d* per acre, and at local prices, £1 6*s* 8*d.* per acre.

Assuming again that each estate has a cultivation of 50 acres, the respective increases at London prices and local prices for the estate with the richer yields would be £106 5s. and £66 5s.'

Observations on the Development of the West Indian Lime Fruit, by Mr. A. J. BROOKS, Assistant Agricultural Superintendent, St. Lucia.

These observations were made for the purpose of ascertaining the exact length of time taken from the flowering period to the maturity of the fruit and to see if the 'Spineless,' lime differed from the 'Spiny' or ordinary lime in this respect.

Individual lime trees growing in the field under ordinary conditions were selected for the purpose of observation, care being taken to choose those trees most sheltered. from strong winds and other conditions which would be calculated to affect the results.

Twenty-four flower buds of the ordinary lime and a similar number of the spineless variety were placed under daily observation as soon as they were large enough to be seen by the unaided eye, and records were made of the length of time required for the petals to fall naturally.

Ten flowers of the ordinary lime, and three of the spineless, set and developed fruit. Careful measurements were then taken at regular intervals during the development of these fruits until their natural fall. The first measurement was taken exactly one month after the fall of the petals.

The average size in diameter of the ordinary lime fruit was then $\frac{11}{16}$-inch and the spineless $\frac{9}{16}$-inch.

A table is given which shows the rate of growth every fourteen days; this is somewhat remarkable for its uniformity, irrespective of wet and dry periods.

It is generally supposed that a period of five months is necessary for the fruit of the lime to reach maturity, but upon reference to a second table it will be seen that only sixteen and a half weeks were required, for the ordinary lime, and nineteen and a half for the spineless variety, to reach that stage.

Cocoa-nuts in Antigua, by Messrs. H. A. TEMPANY and T. JACKSON. Owing to its shortness, this is presented in full:—

As far as information of a definite character can be gathered, in connexion with the growing of this palm in Antigua, it would appear that no large areas were established previous to 1906-7.

There are between 150 and 200 acres under this crop, and the nurseries belonging to the Agricultural Department contain sufficient nuts to plant 50 more acres. It may be interesting to state that the majority of the trees for this area were obtained from the same source, between 7,000 and 8,000 being raised and distributed during the last four or five years.

The young plantations now in Antigua are on a particularly sandy soil, possessing subterranean water—the drainage from adjacent hills. As would be inferred, with a soil such as this, the young plants, for the first three or four years of their

existence, suffer severely from lack of moisture. After this period, however, they make rapid growth.

The time when rapid growth takes place probably dates from when their roots tap the subterranean water supply. Previous to this, the attacks of the scale insect *Aspidiotus destructor*, which is the only one that is of consequence on these trees at the present moment, are somewhat serious. After, however, they appear to be able to combat the ravages of this pest; for the older plants are on the whole particularly healthy.

Probably the earlier planted of the younger plantations will be bearing in three or four years' time.

The growing of cocoa-nuts can only be looked upon as being in the experimental stage; but the experience of the last four years, two of which were extremely deficient in rainfall, would seem to point out that a fair measure of success can be looked for in the future, and that the growing of this crop may add one more minor industry to the meagre number possessed by this island.

With careful fostering, the area planted under this palm in Antigua should reach in the next few years about 500 acres, although a much larger area of suitable land exists in the island.

Manurial Experiments with Cocoa-nuts, by Mr. JOSEPH DE VERTEUIL, Assistant Analyst, Government Laboratory, Trinidad:—

Manurial experiments are being carried on at two cocoa-nut estates in Trinidad and on one estate in Tobago. These are under the control of the Board of Agriculture. There are eight plots on each estate, two of each were only forked and no manures applied. These are kept as control plots.

The manures used in the experiments are as follows: basic slag, bone meal, superphosphate of lime, sulphate of potash, kainit, sulphate of ammonia, nitrate of soda, calcium cyanamide, pen manure and lime. The manures are supplied free of cost to the proprietors, but the cost of application as well as the general cost of cultivation are borne by the estate owners. The manures were spread broadcast, about 3 or 4 feet from the trunk of the trees and 2 feet from the edge of the drains, and the surface soil loosened to a depth of about 6 inches with the aid of a fork. They were applied between May and July, 1911. Records of pickings are being kept from July 1, 1911, and the number of 'selects' and 'culls' from each plot is to be recorded separately. On one estate the experiments are being made in three sections or series; each plot is represented by a single row of palm trees. The plots in one series have received similar treatment to that of the corresponding plots in the other two series.

The age of the trees on the different estates varies from twenty to thirty-five years. They are planted 24 feet apart and the area under experiment on each estate is 8 acres, or 24 acres in all. As these experiments have only lately been started, no record of yields is as yet obtainable.

The Bay Rum and Bay Oil Industries of St. Thomas and St. Jan, by Mr. W. C. Fishlock, Agricultural Instructor, Virgin Islands:—

The bay rum industry of St. Thomas is of recent growth, and is probably centred there partly on account of the existence of a good supply of leaves of the bay tree from St. Jan, and partly because of the low import duties on rum and alcohol that obtain in St. Thomas. In regard to the English islands, the high duties and restrictive legislation in connexion with rum are sufficient to interfere with the development of a similar industry there; but there is no reason why they should not supply the leaves and oil.

The paper gives a description of the bay tree, pointing out that among the names that have been applied to it are *Pimenta acris*, *Myrica acris*, *Caryophyllata acris*, *Caryophyllus racemosus*, and *Eugenia Pimenta*. It is probable that bay oil is made from more than one distinct species, and the writer's observations tend to show that it is obtainable from many varieties of the tree.

Photographs are exhibited to show that there is a large variation in the size and shape of the leaves. The varieties giving oil of the best aroma are usually of a lighter green colour, and more pointed in shape, than those of the inferior kinds; another distinction consists in the tendency of the former to curl. There exists what is known as the false bay tree, or lemoncilla, which is very similar in general appearance to the true bay, but yields an oil that is worse than valueless, as its admixture with the true oil, even in small amounts, will spoil a large quantity of the latter. The only way to distinguish between the two trees is by the smell of the leaves when they are crushed in the hand. Too much emphasis cannot be placed upon the necessity of avoiding the admixture of these two kinds of leaves.

The cultivation of the bay tree has so far been given little attention; but it would seem that there is good reason that systematic culture would be remunerative, and suggestions are given for this.

The recommendation is made that the first picking of the leaves should take place when the trees are four or five years old. It is considered that 15 ℔. of leaves can be obtained from a well-grown tree, five years old; while a tree ten years old will give 60 to 100 ℔. of leaves, yearly. In picking the leaves, the ends of the branches are broken off, but the part picked should only include the green portion of the twigs. It is usual to break the twigs away; the writer recommends the employment of a small pair of shears.

As has been pointed out, all the oil and leaves for making bay rum in St. Thomas are imported, the chief source of supply of the former being Porto Rico. Oil from the English islands is regarded with suspicion in St. Thomas, because it is supposed to be often adulterated with inferior oil. It is known that bay trees of the true variety exists in the islands of Antigua, Barbuda, Montserrat, Dominica and Saba, among others, but makers of the rum are not likely to obtain leaves from these sources, at present, because of the alleged admixture. The inclusion of the inferior oil may be due to carelessness or ignorance; in any case, it is most important that steps should be taken to prevent it.

A description is given of the distillation of the oil and of the preparation of the rum. In the former, two oils are produced, the second of which is darker and heavier than the former; both kinds are used by bay rum makers. In the manufacture of bay rum, the best method is the distillation of the mixture of the rum and oil, though it is also made by blending these two products, with the aid of a little magnesia.

The best prices for the oil are obtained in St. Jan, namely 18s. to 20s. per bottle; the second place is taken by that from Porto Rico which sells at about 16s. per bottle. The bad name of the product from the English islands prevents it from being handled at all by some makers of bay rum, but recent enquiries have resulted in offers of 12s. to 14s. The demand for the oil in St. Thomas is considerable, and growing; and it is also wanted in fairly large quantities in New York.

The conditions necessary for obtaining a high class bay oil include: (a) the use of leaves of good quality, only; (b) the employment of mature leaves, only: (c) the rejection of doubtful kinds, particularly those of the lemoncilla; (d) absolute cleanliness in connexion with the distilling apparatus.

The conclusion is reached that there appears to be an opening for the establishment of a moderate trade in bay oil and dry bay leaves from the English islands to St. Thomas; but that the supply of the best oil and leaves is necessary, in order to gain the confidence of the consumer.

The Classification of Sweet Potatoes, by Mr. W. ROBSON, Curator, Botanic Station, Montserrat:—

The paper deals with attempts that have been made to classify varieties of sweet potatoes in Montserrat, according to a method adopted at the Texas Agricultural Experiment Station.

The basis of the classification is the division of the kinds, first of all into those having: A, split or lobed foliage; B, those having round or entire foliage; and C, those having shouldered or slightly lobed foliage. Each of these divisions possesses further subdivision into: (a) red potatoes; and (b) yellow or white potatoes. There is again a further subdivision in each case, based on the appearance of the veins and the midrib, the classes comprising those having leaves with (1) purple veins, or (2) with green veins and a purple midrib, or (3) with green veins.

The paper gives the classification of varieties in Montserrat according to this scheme, and presents additional particulars of the properties of the kinds of sweet potatoes with which the investigation is being made.

Cassava Starch, by Mr. E. EVERINGTON, Dominica:—

Mention is made, first, of the different uses of starches, and it is stated that cassava starch is equal to, if not better than, the very finest potato starch, for most purposes, and that the cassava root contains 33 per cent. of starch, as compared with 16 per cent. in the potato.

The author considers that many estimates of the yield of cassava, based on small experiments, are extravagant. In his

experience, he has obtained as much as 12 tons to the acre, under exceptionally favourable conditions, but considers that a return of 8 tons is a fair average. He has found, further, that second and third year plantings in the same soil give a larger quantity of the root, but that the starch content diminishes in each year. The bitter varieties give more starch than the sweet. Among those tried, which include kinds from Jamaica, Gaudeloupe and Montserrat, and local varieties, the local kind, Black Stick, has been the most successful; the number of roots on each plant is large; they may be reaped in ten months, and have been known to yield as much as 29 per cent. of starch.

In a general way, cassava starch possesses an advantage over that from maize, in that its manufacture requires only about a quarter of the time needed for the product from the latter. The paper gives details of this manufacture, and draws attention to the necessity for cleanliness and speed in working, and for the employment of pure water.

Particulars are given concerning different kinds of tapioca, and the paper concludes with a description of the manufacture of dextrin and of glucose from cassava starch.

The Water-supply of Antigua, by Mr. H. A. TEMPANY, B. Sc.:—

Owing to the low rainfall and absence of large permanent bodies of water, the question of water-supply is of great importance in Antigua.

The attempt is made in this paper to review existing sources of supply in respect of their origin and chemical composition as determined by analysis.

In all, nearly eighty samples of water are reported on. The analytical data given consist of the total solids, temporary hardness, the chlorine and equivalent sodium chloride, and the oxygen consumed by the organic matter.

The water-supply of Antigua is originally derived from the following sources: (a) surface drainage; (b) rain-water from house roofs and catchwaters; (c) ponds and stagnant streams; (d) springs and wells.

St. John's and about half the country districts are at present supplied with water in pipes from reservoirs. The St. John's supply is derived partly from surface drainage, partly from underground springs. The analyses quoted show the manner in which the composition of the supply varies with the rainfall: at rainy times surface drainage water predominates, the total solids are then low and the organic matter is somewhat high; in dry weather, on the other hand, the spring water is the main source of supply, the total solids then rise to a maximum of between 40 and 50 grains per gallon, and the organic matter shrinks in amount.

The country water-supply, on the other hand, is derived entirely from surface drainage, and possesses, in consequence, more constant characters; the organic matter is somewhat higher, and the total solids range from 16 to 20 grains per gallon.

On the whole, both sources of supply may be classed as moderately satisfactory in quality.

Rain-water collected from roofs, and catch waters, constitute an appreciable source of water for those districts not at present supplied with water in pipes. Such a supply is usually fairly satisfactory, provided the collecting areas and cisterns are free from contamination. Underground cisterns are unsatisfactory, since cracks in the sides and bottom allow of contamination taking place from the soil. Analytical data are produced showing the characters of such waters.

Ponds and stagnant streams also constitute a not unimportant source of supply. When precautions are taken to preserve the waters from casual contamination by human beings and stock, they are moderately satisfactory in character: where no such precautions are taken they are quite unsuitable for consumption; this point is illustrated by analyses. It may be added that the labouring population is cautioned against the use for domestic purposes of water from unprotected ponds, but that this caution is largely disregarded.

Wells and springs also constitute a not unimportant source of water, but the opinion is expressed that this is capable of far greater exploitation than at present.

Geologically, the island comprises three regions. The Northern and Eastern district consists of pervious limestone strata of some considerable thickness, which appear to constitute an underground reservoir of importance: no deep borings at present exist, but shallow wells in many places give abundant water-supply locally. The average quality of the water yielded by these is excellent, though it is somewhat hard. Occasionally, however, shallow wells sunk in this district are found to be salt owing to the existence of shallow surface saline deposits; these however, could probably be penetrated by deeper boring. It is suggested that the development of this source of supply would be sufficient amply to supply the requirements of those parts of the island situated in the limestone area, and also possibly other districts.

The central plain consists largely of a series of non-calcareous sandstones and grits. The underground waters of the central plain are largely salt in character, owing to the existence of saline deposits formed in the bed of the old channel which in late geological times divided the northern from the southern parts of the island. Shallow wells near the southern border of this division are beyond the margin of the salt deposits, and yield moderate supplies of water of a fairly satisfactory character.

The Southern district of the island is underlain by volcanic rocks which have penetrated the older sedimentary strata, and the country is rugged and uneven in consequence; the impervious character of the rocks, combined with the accumulation of alluvium in the bottoms of the valleys, tends to produce in suitable localities an accumulation of underground seepage water of satisfactory character which can in some instances be utilized to supply moderate local demands.

At the conclusion of the session, The PRESIDENT drew attention to an exhibit by Mr. H. Caracciolo, of the St. Joseph's

Nurseries, Trinidad, of cacao seedlings raised from seeds of different maturity, which showed that the seedlings develop best from mature seeds, stating that the matter was of special importance in Trinidad, where it is the custom to raise plants from immature seed rather than from that obtained from properly ripened fruits.

The PRESIDENT drew attention to a handbook that had been prepared in time for the Conference by Mr. H. A. Ballou, M.Sc., Entomologist to the Imperial Department of Agriculture, entitled Insect Pests of the Lesser Antilles. The size of this publication and the diversity of the subjects with which it deals necessarily prevented any consideration of its contents in detail during the sessions of the Conference; proof copies were, however, distributed to delegates, in order that those interested in its contents might have an opportunity of learning their nature and making them the subject of informal discussion. In this handbook an attempt has been made to present in plain and simple language a general account of the present knowledge of the principal insect pests met with in the Lesser Antilles, bringing together in a popular form the information accumulated by the writer during the course of his official duties. It is hoped that the handbook, which contains a very large amount of valuable information and is profusely illustrated, will be found useful to planters, educationists, and to the general public.

The Conference then adjourned until 9 o'clock on Saturday, January 27.

In the afternoon of the same day (Thursday, January 25), excursions were arranged for the delegates to River Estate, to cacao estates in the Santa Cruz Valley and to various educational institutions in Port-of-Spain, the particular excursion being a matter of choice on the part of each delegate.

As has been mentioned already, a number of the delegates and a party from Trinidad were courteously and generously invited by the Hon. THOMAS COCHRANE to visit Point Fortin, on the next day, to see the property of the Trinidad Oilfields Limited. The journey was made on the R.M.S. 'Balantia', chartered by Mr. Cochrane for the purpose, and the party was conveyed to the steamer in two launches, leaving at 7.45 a.m, and 8.10 a.m. After Mr. Cochrane had welcomed his guests on board, the S.S. 'Balantia' left at a quarter to nine, and arrived at Point Fortin at a quarter to twelve, noon, when the party was landed in the steamer's boats, towed ashore by a launch sent from Port-of-Spain for the purpose. The first visit was paid to the store sheds and workshops of the company, and the party then proceeded to the oil wells, where the actual operations of pumping the oil, and of drilling, were witnessed. After spending a very enjoyable time which offered opportunities to most of those present to increase their knowledge of a kind of commercial activity with which they had not before been brought into contact, the party returned to the pier, refreshments being provided on the way, at the manager's bungalow, and subsequently embarked on board the steamer. During the return journey

a lecture was given by Professor P. CARMODY, introduced by Dr. FRANCIS WATTS, C.M.G., on The Petroleum Industry of Trinidad, the lecture being illustrated by samples of the fractionated products and by-products of the wells at Guayaguayare. Subsequently, another meeting was held, in the dining saloon of the 'Balantia', for the purpose of the presentation of a paper on Trade Reciprocity between Canada and the West Indies, by Mr. C. SANDBACH PARKER (British Guiana). This opportunity was taken of reading the paper, in order to clear the way for a formal presentation of a resolution on the subject at a regular session of the Conference. It is reproduced in full, together with the proceedings, as follows:—

Dr. WATTS, in introducing Mr. Parker, said he was sure that the important subject he was to deal with would be attentively listened to. It would also prepare the delegates for more cut-and-dried results when they met at the Victoria Institute to deal formally with that question.

Mr. PARKER, who was greeted with applause, said that he was glad to have the opportunity of putting his draft resolution before them so as to enable them to think about it before they met on Tuesday next. His resolution was as follows:—

DRAFT RESOLUTION.—Be it resolved:—

(1) That the members of this Conference, representing Agricultural interests throughout the British West Indian Colonies, consider that the future prosperity of those colonies can be best served by the conclusion at an early date of a reciprocal arrangement with Canada based upon preferential treatment strictly confined to articles produced within the British Empire, as recommended in the report of the Royal Commission on Trade Relations between Canada and the West Indies.

(2) That copies of this resolution be forwarded to the Prime Ministers of Great Britain and Canada.

Mr PARKER then read the following paper:—

RECIPROCITY. The resolution which I have asked our President to allow me to submit to your consideration is, I think, of the gravest importance. I understand that there is a disposition in certain quarters to abandon any attempt to get rid of the right at present given to Canadian refiners to import 20 per cent. of their requirements in Foreign Sugar at the B. Preferential rate. I venture to think that this attitude, if maintained, will prejudice our position under the preference. With your permission I will briefly explain my reasons and give you my suggestions. (1) So far as I am aware, there is no other article on which a Preference is given to British Imperial products which is not strictly confined to articles made within the British Empire. (2) The permission to import 20 per cent. Foreign Sugar at British Preferential rates means that to the extent of 20 per cent. we share that preference with other foreign nations, which are not specified and without payment. Why should this privilege for which we are now to be asked to pay be given to others without similar payment? It seems obvious to me that if the Preference is to benefit British products to the extent for which they are to be asked to pay, it must be confined to British products, and not shared by others. (3) The preference

under present circumstances goes chiefly to Canadian buyers, not to us. I do not want you to think for one moment that I am one of those who complain that we get no share of the preference under the present tariff; on the contrary I know that we do, but the difficulty is that we never know what amount of preference we can secure, because we are always told when we offer sugar that other sugar, preferential or non-preferential is offering lower, and it is only at certain times of the year that we are able to exact some share of the preference. The question for us therefore carefully to consider is—What is the real value of the preference, and how much ought we to pay for it? (4) We are told that the real value to us is the entrée to the Canadian Market, which we have not got in other markets. I would be the last to dispute this, but I do strongly maintain that that entrée would be as certain with a preference of 5c. per 100 lb. as it is with the present preference of 31c., and that unless we are going to be able to count upon receiving more than that share of the preference, we should be ill-advised to enter into an agreement to pay more than that price for it. In giving evidence before the Royal Commission on Trade Relations, both Sir Nevile Lubbock and I stated that we would prefer 15c. preference strictly confined to British sugar then 31c. with the privilege to the refiners to import 20 per cent. of foreign sugar upon the same terms. That is still my view. (5) I understand that the refiners are not content with 20 per cent. Foreign at British preferential rates, but are agitating to have that increased to 50 per cent. mainly on the ground that the British West Indies cannot supply their requirements. I think there is no justification for this assertion. In a White Paper issued by the Board of Trade, and laid before the House of Commons in August last, the total imports of sugar into Canada from all sources is stated as follows:—

Year ending March 31	1908	217,814 tons
,, ,, ,, ,,	1909	208,909 ,,
,, ,, ,, ,,	1910	226,003 ,,

of which the imports from British West Indies including British Guiana were

	1908	161,521 tons
	1909	138,136 ,,
	1910	131,252 ,,

while the exports from British West Indies and British Guiana and British Honduras were

	1908	226.494 tons
	1909	208.847 ,,
	(1910	not available.)

From these figures you will see that British West Indies exports have just balanced the total Canadian imports from all sources. But these figures have to be modified

(1) by the fact that a large amount, probably some 60,000 tons per annum, is imported to Vancouver, practically none of which comes from the British West Indies.

(2) Against this, some 30,000 tons of the British West Indian exports is in the form of yellow grocery sugar sent to England for direct consumption. This quantity is constantly being reduced, while the Vancouver imports are constantly increasing.

(3) I am sorry that, being away from my papers, these last figures are estimated; but I do not think they will be found on the wrong side.

(4) The conclusion I draw from them, which I think you will share, is that up to now there is no justification for saying that British West Indies production is insufficient to supply the wants of the eastern ports of Canada.

(5) Furthermore, I have little doubt that if we have any arrangement with Canada under which we can count upon getting a ready market in Canada at a price better than other markets to the extent of even half the nominal preference of 31 per cent., our export can be sufficiently increased to supply the requirements of the eastern ports for some years to come. Capital would be attracted to our colonies, improved methods of manufacture would be adopted, and the output of sugar thereby immensely increased. Take Antigua. I believe there was at one time over 50,000 acres in sugar cultivation, whereas to-day there is only 15,000 acres in cane, and the crop is about 13,000 tons. This could be increased by modern manufacture by at least 4,000 to 5,000 tons from present acreage, and there is little doubt that a secure market at preferential rates would lead to an increase in the acreage cultivated. The same may be said of all the British West Indian Islands.

(6) We are also assured that the preference secures to us now a ready market at all times in Canada. This is not so. There have been many instances during the past year when practically no transactions have taken place, and we have been forced, in order to make sales, to accept a price barely equal to that obtainable in New York or the United Kingdom. In New York or the United Kingdom it is nearly always possible to make sales at market price, but in Canada there are practically no buyers except the refiners, who by the operation of the 20 per cent. foreign privilege are able to refrain for considerable periods from purchasing British West Indian sugar.

(7) The Canadian refiners complain that they are precluded from giving more of the preference to us by competition from sugar refined from British-grown sugar in the United Kingdom and imported to Canada at preferential rates—also that the through rates of freight to inland towns in Canada are lower from Greenock than from Montreal. The fact remains that the freight from the West Indies to the United Kingdom is considerably higher than from the West Indies to Canada, and that heavy landing and ships' charges have to be incurred in the United Kingdom. It is therefore plain to me that the United Kingdom would not secure one pound of British West Indian sugar, were the Canadians only to concede any considerable part of the preference in their price to British West Indian sellers.

(8) The question of the distribution of the benefits of preferential rate of duty is one which cannot be laid down by Government, and which must be left to the ordinary commercial bargaining between buyer and seller; but it is clear that before we pay for any given amount of preference, we must be sure that we shall get it. So long as the privilege to import any proportion of foreign sugar at the British preferential rates continues, we can have no assurance that we shall reap the full benefits for which we are to pay. It is easy to prove that the Canadian revenue is poorer by the difference between the ordinary and the British preferential rate of duty, but it is equally easy to

show that only a small proportion of this difference has reached the West Indies, and that the amount received by West Indian sellers is becoming less owing to the operation of the 20 per cent. Foreign. For this reason I urge strongly upon you the desirability of passing this resolution.

I fear that the desire on the part of those who import Canadian products to the West Indies, to see a preference given on those products is at present blinding the eyes of those responsible for the Government of the West Indies to the real operation of the preference coupled with the liberty to import a proportion of foreign sugar at British preferential rates, and that unless their eyes can be opened in time, we are in grave danger of entering into an agreement for mutual preference the cost of which will mainly fall on the planters, while the benefits will be prevented from reaching them by the operation of the 20 per cent. foreign clause.

In conclusion, may I state clearly that I am strongly in favour of a reciprocal arrangement between Canada and the British West Indies, provided that the preferences are confined to British produced articles; but that if the permission to import any percentage of foreign goods at British preferential rates is to be accepted, some arrangement must be made which will enable the parties to the arrangement to secure the full benefits for which they pay, which is not the case at present.

I have I think shown that a considerable quantity of British West Indian sugar has been shut out of Canada by the operation of the 20 per cent. Foreign Clause. I think it will be found to amount to some 40,000 to 50,000 tons per annum. This has been replaced by Foreign sugar imported at the Preferential rate from Foreign sources, which was purchased because sellers asked for some portion of the benefit of the Preferential rate and Canadian refiners were unwilling to give it to us. I do not complain of their buying the sugar which was cheapest for them, but I wish to draw attention to the fact that the privilege given to them of importing any proportion, however small, of their requirements in foreign sugar, at the British Preferential rate, not only drives a certain amount of British West Indian sugar to seek a market elsewhere, but enables the Canadian buyers to utilize this right to force us to sell at practically the same bond price as they can purchase any other foreign sugar offering, thereby not only minimizing the benefit which we sellers can secure under the preference, but practically reducing the benefits of Canadian preference obtainable by sellers to a bare preference in even prices over foreign sugar, whenever there is any obtainable. The practical effect in Canada is that, while the Canadian market sacrifices a large amount of revenue in order to secure that British West Indian sugar shall supply their market; the permission to import 20 per cent. foreign, and the privilege to beet factories of importing 2 tons of Foreign beet for each one of Canadian grown that they melt, at British Preferential rates enables the Refiners to draw their supplies from a larger area than they require, and so to divert a very large proportion of the revenue so sacrificed to their own products.

The American system of preference operates in a way which is much fairer to Preferential sellers because it is strictly confined

to the produce of specified countries, and there is no right to buyers to go into the world's market and purchase a portion of their requirements at the preferential rate. This is my reason for maintaining that the privilege of importing any proportion at the British preferential rates should be withdrawn as a condition of any reciprocal preference to be given by us.

After some discussion, in which Mr. E. R. Davson, Mr. F. A. C. Collymore, Mr. W. Gordon-Gordon, the Hon. J. S. Hollings, Mr. A. P. Cowley, Mr. E. A. Robinson and Sir Frederick Clarke, K.C.M.G., took part, Mr. Parker replied briefly and the meeting dispersed.

At the conclusion of the reading of Mr. Sandbach Parker's paper and the discussion to which it gave rise, Dr. WATTS stated that he thought he would be voicing the wishes of the assembly in according to Mr. Cochrane their greatest thanks for the very unusual and generous treat that he had afforded them that day—an announcement that was greeted with prolonged applause. In reply, Mr. COCHRANE thanked Dr. Watts, His Excellency the Governor and all present for the genuine pleasure that had been afforded him by the acceptance of his invitation. He made reference to difficulties that required removal before the work that is being done in connexion with the development of the oil industry will be facilitated, and referred to the importance of this work in connexion with the exploitation of the resources of the British Empire. It was likely that the development of the oil industry in Trinidad would lead to the provision of cheaper fuel for the sugar factories, with the consequent lessening in the cost of production of sugar. He was pleased that the expedition had been an enjoyable one, and he thanked the members of the party for having accepted his invitation.

During the journey to Point Fortin, a meeting of the Committee on Scientific Nomenclature was also held; opportunity was taken, in addition, for informal discussion among members of the Agricultural Conference of matters of agricultural interest in the West Indies. The party finally reached Port-of-Spain late in the evening.

In the evening of the same day (Friday, January 26), an address on Rubber Cultivation, illustrated by lantern slides, was given by Dr. P. J. S. CRAMER, Director of Agriculture, Surinam, at the Victoria Institute. Among those present were His Excellency Sir George Le Hunte, G.C.M.G., attended by Lieutenant Bindley, Assistant Private Secretary; Dr. Francis Watts, C.M.G., and a few of the delegates to the Conference, the number in the audience being small on account of the late return from the oil fields at Point Fortin. The lantern illustrations were shown by Mr. J. B. Rorer. The following account of the proceedings is taken from the *Port-of-Spain Gazette* for January 28, 1912:—

Dr. WATTS briefly introduced the lecturer, who then invited the audience to accompany him in a short trip to the Rubber Industry in the East Indies, but before doing so, he felt it necessary to apologise for his English. He hoped they would take the good intention for the deed; and if he did not express

himself quite perfectly they would bear in mind that he addressed himself more to their eyes than to their ears. A series of slides was then projected, beginning with the work to be done in changing the jungle into a rubber field. The lecturer then dwelt on the nature of the soil and climate suitable for rubber, a loose soil being preferable, as obtained in the Malay States. Nurseries were then dealt with by the lecturer, who advised that a matter of utmost importance was that seeds should be gathered from healthy trees, and in this connexion he gave the opinion that seedlings should be kept without shade, as they grew better in that state. The upkeep of the trees, a general description of the various methods of tapping, followed by scenes descriptive of the process to which the latex is subjected in order to produce the finished product in the rubber factory, brought the lecture to a close.

Dr. WATTS, in thanking the lecturer, said what he had told them was very interesting to rubber growers, as he showed them that if mistakes had been made in agricultural matters, they would be rectified. If he had also shown them how mistakes that had been made in the East could be avoided in the West, he had done a greater service. He felt sure the pictures would have a stimulating interest, and serve to expedite the progress of rubber-growing in the island. They were also to have had some slides on rubber in British Guiana that evening, but it was impossible to begin a new lecture at that late hour, so that if Mr. Leechman consented, his remarks would be postponed until Monday evening. He desired to thank His Excellency the Governor for attending, particularly as it must have been at personal inconvenience, owing to the late arrival of the 'Balantia' from the oilfields excursion.

The proceedings then closed.

The sessions of the Conference were resumed on Saturday, January 27, at 8 a.m., when papers and discussions relating to cotton were taken.

COTTON.

The first paper read was entitled The Results of the Cultivation of Cotton in St. Vincent, by Mr. W. N. SANDS, Agricultural Superintendent, St. Vincent. It dealt with the following points :—

A paper on this subject was submitted to the West Indian Agricultural Conference held at Barbados in 1908, and the one now presented has been written in order to bring the story up to date.

Steady progress has continued to be made with the cultivation of cotton, with the result that the cotton industry is now the premier industry of St. Vincent. It is of interest to record that the value of the exports of Sea Island cotton and seed, alone, during the last fiscal year exceeded £1 per head of the population, the population of the Colony on April 1, 1911, being 41,877. Not much progress has been made with the growing of Marie Galante cotton in the St. Vincent Southern Grenadines, but the outlook for the future is hopeful.

The exports of cotton lint in the financial year 1903-4 amounted to 43,302 lb., valued at £794 only; whereas, last year, 540,339 lb. was exported, of an estimated value of £41,836.

The estimated value of last season's crop of Sea Island lint and seed was £45,874, and that of Marie Galante lint and seed £1,178, the total estimated value being £47,052. This clearly shows what a valuable asset the industry is to St. Vincent. The figures given are those for the crop year, October 1 to September 30.

The areas planted in cotton last season were stated to be 3,587 acres of Sea Island, and 1,093 acres of Marie Galante. The acreage returned as being under Marie Galante was, however, considered to be much in excess of the actual area under cultivation.

The average yield of Sea Island cotton per acre for the past six years is 150 lb., only. This low yield is in a large measure due to the heavy rainfall of many of the districts favouring the growth of bacterial and fungus diseases.

The yield of Marie Galante cotton per acre in the Grenadines is very low. Last season it was only 24 lb. per acre, if the acreage returned is correct. The lint percentage of the seed-cotton is also low. Seed of a better type of Marie Galante, and also seed of the fine Sakellarides Egyptian cotton, have been recently introduced with the object of improving the yield and quality of the cotton grown in the islets.

There are four ginneries in the Colony at the present time. The Government Central Ginnery is the largest,, with eight gins. The second is the Kingstown ginnery with five gins. The two others are on estates, but only two and one gins respectively, are worked.

The Central Ginnery dealt with about half of the output of Sea Island cotton and six-sevenths of the Marie Galante. Last season's ginnings of Sea Island white seed-cotton from estates gave 24 per cent. of lint; that of small growers 26·5 per cent. The percentage of stained Sea Island cotton on white cotton was over 14.

The average lint percentage of Marie Galante seed-cotton was 24 per cent., only.

The low lint percentage of seed-cotton from estates was due to the fact that several of them grow extra fine types of Sea Island. These gave from 22 to 24, only.

At the Central Cotton Ginnery also, cotton is purchased from small growers on a profit-sharing basis, and the scheme has proved a success. Last season seed-cotton equal to 212 bales was purchased, as against 67 in the previous season. A still greater volume of business is being transacted this season.

There has been a considerable extension of Sea Island cotton planting by the peasantry during the past two years. This was due to the inauguration of the Government's Cotton Purchase Scheme and the favourable price paid by licensed dealers for seed-cotton. Last season there were 562 small growers with 916 acres under cultivation, and it is estimated that a larger area has been planted by them this season.

Specially tested, selected and disinfected seed is supplied by the Agricultural Department at 5c. per lb., which is practically cost price. The advantage derived by the small growers in being able to obtain good seed so readily for planting cannot be over-estimated; besides the quality of their produce is maintained.

In order to protect and safeguard the cotton industry in respect of pests and diseases, an Ordinance was passed in 1910 making it compulsory on all cotton growers to burn their old bushes at the end of each crop. In St. Vincent all bushes had to be destroyed before April 30 in each year, and in the Northern Grenadines before March 31. The Ordinance does not apply to the Southern Grenadines, where the perennial Marie Galante cotton is grown.

Steady progress has been made with implemental tillage and a considerable extension of this form of cultivation is to be looked for in the near future. Many estates now suffering from a short supply of male labour will be able to give considerable areas of their lands better cultivation if they adopt the system introduced by the Agricultural Department. The value of pen and other organic manures for cotton is now generally recognized, and the preparation of these and the growing of plants for green dressing purposes are being carried out on extended lines.

In St. Vincent, where only Sea Island cotton is grown, seed for planting is obtained from fields with plants of desirable field characters, producing lint of good quality. The seed is all selected, tested and disinfected before planting. In selecting the seed, only the heavy, sound, tufted seed is retained. This practice has been adopted by the Agricultural Department and planters since 1905, with the result that the local type has been kept pure and the quality of the lint maintained.

The rainfall of St Vincent, both of the Leeward and Windward coast lands, is heavy. This, with the light soil, enables a fine class of cotton to be grown, but it also favours the growth of various diseases. A very important line of work, therefore, which is being carried on by the Agricultural Department, is the selection of plants showing resistance to disease, more particularly the bacterial disease which causes angular spot, bacterial boll disease, and black arm. During the past two seasons a considerable amount of work has been done in this direction, and although the present season's experiments are not closed some very encouraging results have been obtained. It is estimated that many estates in the island lose, in average seasons, 25 per cent. of their crop from this disease alone; and in a wet season like the present, some estates have lost quite 75 per cent. If a desirable variety can be raised which is immune to disease, or even nearly so, it would place the local Sea Island cotton on a much better footing.

The cotton worm (*Alabama argillacea*) is not a serious pest, and no attack has been recorded during the past four seasons. Its chief natural enemy, the Jack Spaniard (*Polistes annularis*), is preserved in all districts and is well distributed.

Other pests which occur locally and do some damage each season are the cotton stainers (*Dysdercus delauneyi*), black

scale (*Saissetia nigra*), and leaf-blister mite (*Eriophyes gossypii*), and a small bronze leaf-eating beetle.

This was followed by a paper, by Mr. H. A. TEMPANY, B.Sc., Superintendent of Agriculture for the Leeward Islands, dealing with The Cotton Industry in the Leeward Islands. This was on the lines of a paper with the same title, published in the *West Indian Bulletin*, Vol. XII, p. 7, and supplemented some of the information given there.

A paper by Mr. J. R. BOVELL, Superintendent of Agriculture, Barbados, on the Cotton Industry in Barbados, was next presented, and is abstracted as follows :—

The paper commences by giving a table in illustration of the fact that the yield of cotton in Barbados has become about one half of what it was when the cotton-growing industry was first re-introduced. Reference is made to the experiments that were undertaken by Mr. Thomas Thornton, Travelling Inspector in connexion with the cotton industry, under the Imperial Department of Agriculture, which were conducted by him until he left the island at the beginning of 1908. Mr. Thornton's method was to select seed from the best plants giving the best lint, the plants having been grown from seed from the Sea Islands. Since Mr. Thornton left the island, the experiments have been carried on, and largely extended, by the Local Department of Agriculture.

At the present time, the experiments are conducted in two series. In the first, the plants are self-fertilized for subsequent seed selection ; this work is carried on in co-operation with planters in the island and on land rented from Waterford plantation by the Government. At Waterford, trials of varieties of cotton are also being made.

The second series, in which selection is made after cross-pollination under conditions which ensure that the parentage of the resulting plants will be known, is conducted at Waterford plantation, also. The crossing is effected between plants grown from selected forms of Sea Island and indigenous cotton plants, as well as with plants that are found in fields, in a healthy state, while those around them are attacked by disease. The details of the field work required are given in the paper. So far, the results confirm those obtained by O. F. Cook, of the United States Department of Agriculture, and detailed in Bulletin No. 147 of the Bureau of Plant Industry of that Department, entitled Suppressed and Intensified Characters in Cotton Hybrids. The main results of this worker are quoted from the bulletin.

The circumstance that the number of hybrids will increase largely in the future has led to the adoption of a special means of registering them, which is described in the paper, and a list is given of the hybrids first obtained, the names of their parents, the number of plants in the plot in 1910, the number of plants like the male parent, the number like the female parent and the number which varied so considerably that they did not resemble either parent. The list shows that a comparatively large number of the plants resembled neither of the parents.

The plants also varied greatly among themselves, especially in the characters of tallness and bearing power.

Evidence is presented showing the difference of behaviour of the same seed when used in different districts or islands. Assistance of a most useful nature has been given by the commercial valuation of the lint, carried out during the past three years by Mr. C. M. Wolstenholme, of the firm of Wolstenholme and Holland, of Liverpool. A table is included showing the results of such examination. There are also included a list of the cotton seed selection experiments carried on with the co-operation of planters, and a list of the varieties of cotton under cultivation on the Government experiment plots.

The paper concludes with the following: 'As showing the importance to Barbados of the cotton industry, I may mention that during the past five seasons, 1906-7 to 1910-11, there has been grown 28,824 acres of cotton which yielded, on an average, 4,529,870 ℔. of cotton lint of the value of £285,746, and 11,144,421 ℔. of seed of the value of £24,791, making a total of £310,537.

'In conclusion, I may say that not only is the cotton industry in Barbados of importance as an industry in itself, but it is also very important for furnishing a remunerative rotation crop, especially for growing in suitable districts, in substitution for the sugar-cane in those fields in which that plant is being attacked by the root disease, *Marasmius sacchari*; and I consider that these experiments to which I have just been referring, and which have for their object the improvement of Sea Island cotton in Barbados, are of the highest value to the Colony.'

Mr. THOMAS THORNTON (Tobago) followed with an address on The Cotton Industry of Tobago, in which he first pointed out that little experimentation was done, at the commencement, with cotton in that island, chiefly because of the poor yields that were experienced. He had commenced trials of Sea Island cotton there, about four years ago, and these had proved a failure: the yields were poor, and cotton stainers caused much trouble. He therefore continued the experiments in hybridization that he had commenced in Barbados, under the Imperial Department of Agriculture, and had produced a successful cross between the Sea Island type and a form of cotton native to Barbados. There was about 120 acres of this cotton growing in Tobago, at the present time, and plants were also being raised in Trinidad. The plants are vigorous, and produce good cotton: the percentage of lint to seed-cotton is, however, rather low, and the bolls are somewhat small. The experiment, last year, had nevertheless afforded a yield at the rate of 333 ℔. of lint per acre, and the cotton sold at 14*d*. per ℔. and this under conditions where it had been impossible to grow Sea Island cotton. He expected lower returns this year, on account of the abnormally large rainfall that had been experienced in the planting season and in June and July. The peasant growers had taken up the cultivation of the hybrid to a large extent, and it was giving them satisfaction. Further, the speaker, himself, had seen a sample of the lint, and considered it to be very good.

Mr. J. W. MCCONNEL (England) then gave an address dealing with Cotton Production and Manufacture. The speaker first

of all expressed his pleasure at being present at the Conference on the kind invitation extended to him by the Commissioner of Agriculture and confirmed by the British Cotton Growing Association. He spoke of the rather exceptional circumstance that cotton is one of the few products of the West Indies whose characteristics and value can only be determined when it is put through the further processes of manufacture for which it is required. There was no doubt that the West Indian planters were growing the kind of cotton that is most suited to the conditions that obtain, that is to say Sea Island cotton; but this kind was the most difficult to judge, as regards its value. The spinners who use it consider that they can form a judgment of it after examination, but the best indications of its worth are obtained from its behaviour in the machines. As regards the type that should be grown, he thought that the matter of first importance was the production by selection or other suitable means, of healthy plants, which bear well. The second requisite was that the product should be strong in staple—a quality that, actually, is a special characteristic of West Indian Sea Island cotton. Coupled with this was the very important factor of regularity of staple, in order that the weak places in the yarn produced in manufacture should be as few as possible. He thought that this matter of regularity of staple was very largely an affair of good agricultural conditions, and particularly of proper and continuous selection. The best cotton would possess irregularities, but the condition to be aimed at was the reduction of such irregularities to the lowest possible proportion. The speaker then turned to the subject of 'neppy' cotton, first explaining that by 'nep' is meant the small clusters of weak fibres, varying in size, that are found on the cotton after it has been combed to form a fleece; most generally it was still present, even when the cotton had been combed—as is the case in the mills that produce the finest yarns—as much as three times. The characteristic was exhibited by all fine cottons. The effect of its presence, as regards the manufacturer, was that it made it impossible for him to produce clean yarn; and in the effort to obtain this, two unfavourable circumstances arose: firstly the amount of yarn obtainable from a given weight of cotton was lessened to a serious degree, and there was a large wastage; and secondly, the manufacturer as a result, was only able to use about one half of the cotton for which he had paid. Egyptian cotton was much cleaner (freer from nep) than that from the West Indies, and he thought that the reason for this is the circumstance that it is produced under more uniform conditions, namely those of irrigation: the plant is supplied with food regularly, during its period of growth, so that it thrives better and the fibres on the seeds mature more regularly than is possible under the conditions of intermittent rainfall. Improvement by selection was one of the remedies for the presence of weak fibres, and it was thoroughly recognized by the speaker that those responsible for the work were paying adequate attention to this matter. As regards the kind of cotton that should be produced, it was Mr. McConnel's opinion that this would to a certain extent decide itself automatically: the kind would be grown that would afford the best combination of large production and

value per pound. The progression toward better kinds should be gradual – not a matter of attempting suddenly to obtain and exploit a very superior grade of cotton; the speaker's experience of these matters, extending now over thirty years, showed that the best and largest demands for yarns are always requiring a better cotton. As far as the market is concerned, he would give it as his opinion--he was not speaking for the British Cotton Growing Association, or for the Fine Cotton Spinners' and Doublers' Association – that the supply of cotton would continue to be short of the world's requirements, and that the general tone of prices will therefore be higher than it has been during the past five or ten years. In regard to the prices for American cotton, he had been told by a native of the country that these could never remain low for one or two years in succession, partly because the grower in the South is much more versatile than he used to be, and would readily grow things in the place of cotton if he could not get a fair price for it; and because the cost of production in the United States had increased. These matters were important because American prices regulate those in other markets. He believed what he had been told about this, and that cotton-growing is worth the attention of agriculturists wherever the plant can be raised.

The PRESIDENT expressed appreciation, on behalf of the members of the Conference, of the remarks made by Mr. McConnel, alluding to the particular usefulness of the fact that he was able to present a phase of thought and knowledge that his audience could not possibly possess: they were now able better to appreciate the views of the buyers of cotton, in regard to cotton production. It was a gratifying circumstance that Mr. McConnel was able to express satisfaction with much that had been done for the cotton industry, in the West Indies, and it was infinitely useful that he was in a position to point out the defects of the work; it was certain that what he had said would cause greater attention than had ever been afforded, to the matter of nep in cotton. The growers of cotton were now beginning to appreciate the relative values of the different qualities of cotton, and the help that Mr. McConnel had given in this relation would be of the greatest use. He now invited discussion of the points that had come under notice.

It was stated by Mr. J. R. BOVELL (Barbados) that nep had been attributed to bad ginning, but he had been able to show that this is not the true cause; it was his opinion that the breeding experiments with cotton should be so arranged as to eliminate this character. In regard to the variation shown by the same type of cotton under different surroundings, he thought that matters would go so far eventually that different cottons would come to be grown in different districts. Mr. T. THORNTON (Tobago) referred to experiments conducted by him in Barbados, under the Imperial Department of Agriculture, in which it had been found possible to reduce the percentage of weak fibres from thirty to seventeen or nineteen, after two or three years' work. In regard to the variation according to circumstances that Sea Island cotton had shown, it was certain that this was the cause of the difference in

the product from the various islands. He did not agree with Mr. S. SIMPSON (England) that the possession of nep was due to the ill health of the plants. It was the opinion of the Hon. J. S. HOLLINGS (Nevis) that the feature is due to irregularity of nutrition of the plants providing the fibre, and this speaker made comparison with the freedom from nep of Egyptian cotton, grown under irrigation—a comparison that did not appeal to Mr. Thornton, on account of the difficulties in comparing cottons of two different types in respect of one particular supposed to be produced by different treatment. Mr. Thornton, further, indicated that the fact was connected with the unequal nutrition that arises from the ununiform distribution of the fibres on the seed—especially on clean black seeds.

The PRESIDENT laid stress on the important nature of the reasons that had been adduced by Mr. Thornton for the production of weak fibre, in cotton; and suggested that his views concerning the matter should be published, in order that there may be evidence as to the extent to which his work has proceeded. The knowledge that cotton seed possesses an area where the fibres are weaker than the rest made it appear that one of the first aims in breeding should be to reduce the extent of that area. It is recognized that cotton varies also with the uniformity, or otherwise, of the season in which it is grown; so that there were two factors in connexion with irregularity of staple: unequal distribution of the fibres on the seed, and lack of uniformity in the conditions during the growing season. The matter was so evident that there should be no longer any confusion of the subject in the direction of attributing the condition to unripeness of the cotton; planters did not usually pick immature cotton, and when this is spoken of, there should be definite knowledge as to what is meant. Mr. McCONNEL expressed his agreement with the reasons for irregularity, mentioned by Dr. Watts, and was certain of the existence of the area of weaker fibre, on the seed, spoken of by Mr. Thornton. He was convinced, however, that nep is produced during ginning, and it is also increased in amount by the various operations of spinning. The irregularity of staple was not only confined to different areas of the seed, but the cotton varied in different bolls and even on the seeds in the same boll, and he believed that the causes were irregular nutrition, unhealthiness of the plants and the attacks of insects, especially of cotton stainers. Lieut.-Colonel F. C. TROLLOPE (Barbados) cited a case from his experience of cotton-growing in Barbados, in which the usefulness of irrigation had been shown unmistakably It was the opinion of Mr. A. W. HILL (England) that weakness of fibre, and nep, are due almost entirely to faulty nutrition—not so much of the plant, but of the individual seeds: there may be too many seeds in the boll or too many fibres on a certain area of the seed, so that, speaking from a botanical point of view, one of the aims of selection should be the production of seeds with lint distributed evenly over the surface. Mr. Hill was assured by Mr. J. R. BOVELL (Barbados) that attention was given to this matter in cotton improvement, in Barbados. Lastly, Mr. F. R. SHEPHERD (St. Kitts) drew attention to a sample of cotton exhibited by him which had received a report from the British Cotton Growing

Association, and formed a practical illustration of the fact that what spinners call dirty cotton, is lint containing a large proportion of nep.

This part of the proceedings was succeeded by an address, by Mr. THOMAS THORNTON, A.R.C.S. (Tobago), on the subject of The Experimental Hybridization of Cotton. The speaker commenced by stating that, when he was connected with the Imperial Department of Agriculture, some years before, he had noticed in the cotton fields, particularly in Barbados, plants that appeared to have their origin through natural crossing with the native cotton, and had been able to verify the existence of these by actual experimentation. This had stimulated him to further action in the matter, and it was his intention now to give a very brief account to show how the production of first cross cotton seed on a large scale may be made a matter of actual practice. The first cross gave a very large plant which produces a greater quantity of cotton than either of the parent plants, and the fact had formed a basis for increasing the scale of the work with first cross seed. In the second generation, every class of cotton was obtained from plants showing all stages of resistance to disease; while the third generation comprised plants, few of which were of any value, but included some stable forms which moreover were not comparable as regards size and productivity with the plants from the first cross. Seed from plants that appeared to be of most use has been reserved, and a further generation has been planted out; this has produced plants showing stable characters that cannot be compared with those from the first cross, probably partly on account of the untoward conditions of weather that were experienced. Work of this kind should, however, be capable of affording good results; but it requires to be supervised by those who can give it undivided attention. He would also suggest that a survey of the types of cotton indigenous in the West Indies, and the crossing of these would be useful; it was quite possible that a number of forms that are regarded as types are not really of that nature, but hybrids. Among crosses that had been made by the speaker, were those employing Barbados native, Tobago native and Marie Galante. Reverting to the original subject, Mr Thornton stated that he had come to the conclusion, as the result of his experiments, that though efforts should be made to obtain fixed hybrid cottons, the production of a first cross on a large scale should be made use of until a good fixed type shall have been obtained. He then described the means of obtaining seed of a first cross on a large scale, and the tools that had been devised by him for the purpose, stating that 300 to 360 flowers can be cross-pollinated by two girls in one day, and that, estimating that 100 flowers will give the seed required to plant an acre, it costs, under the conditions in which he had worked, about 1*s*. 6*d*. to produce a number of first cross seeds sufficient to plant an acre af land.

Mr. W. ROBSON, Curator of the Botanic Station, Montserrat, followed with a paper entitled Cotton Selection in Montserrat,

which brought forward the following points:—

The earliest efforts in cotton selection in Montserrat were confined to the Experiment Station, but at the present time, particularly under circumstances of peculiar soil conditions, the work of selection has been carried out on estates, the lint from the chosen plants being examined at the Experiment Station and the seed returned to the planter for propagation. In cases where the soil conditions are similar to those at the Experiment Station, seed is supplied of the cotton showing the best record, and this is submitted to trial on plots on the estates, for the purpose of ascertaining the suitability to particular districts

The most comprehensive series of tests is now being made by the Agricultural Department on land near the Experiment Station, placed at its disposal by Mr. Penchoen, Attorney to Messrs. Sendall and Wade.

Information to be employed as a control in the valuation of the lint is obtained by submitting samples which are kindly reported upon by Mr. C. M. Wolstenholme, at Liverpool, and by sending larger samples for spinning tests carried out by the courtesy of Mr. A. H. Dixon, of the Fine Cotton Spinners' and Doublers' Association, Limited, Manchester.

The work of selection is complicated by the fact that the obtaining of a strain of cotton without defect either in the field characters or in the lint is a difficult matter, and through the circumstance that, occasionally, selected plants do not breed true; such plants have been regarded as possessing the characters of hybrids, and an illustration is presented from the work in order to demonstrate their nature.

Attention is being given to the introduction of new strains for trial, and the suggestion is made that, while large plantings of seed of outside origin are not to be recommended, new seed may be useful for providing plants from which selection may be begun. The paper concludes with a consideration of the deterioration of cotton seed during storage, and of methods of preventing this.

After the reading of this paper, on the invitation of The President, the Conference was addressed by Mr. W. Marsland (England), who commenced by stating that, although his knowledge was one of cotton-spinning rather than of cotton-growing, he had been very much impressed by the number of experiments that are being conducted in the West Indies, not only with cotton but with many other crops. For its part, cotton appeared to be receiving its full share of attention. He thought that the giving of so much attention to cotton was eminently advisable, because no crop could be grown in this part of the world that would be eventually subjected to such a searching test as that undergone by cotton, before it is put to its final use. Cotton can be made to undergo a test in cotton mills, which is infallible, for the temperature and the condition of the atmosphere of the rooms are under complete control, and the machines dealing with the lint can always be adjusted to give a product

of the same kind, provided that the cotton is uniform in character. This therefore led him to consider that cotton should be grown, in every season, under as nearly the same conditions as possible. Proceeding, he was glad to see that the efforts of the British Cotton Growing Association had benefited the West Indies, and he was also pleased to feel that the benefit is mutual. It was only natural that the Lancashire cotton spinner should wish to obtain as good cotton as possible, as cheaply as he can. The British Cotton Growing Association had desired, however, that while the cotton from the West Indies, should be good, uniform, strong and cheap, at the same time the Association was anxious that the planter should be properly remunerated for the work that he had done in raising the product. The speaker hoped, further, that the experimentation with cotton would continue; there could be nothing contrary to nature in what is being done, for the cotton that is undergoing improvement in order that the manufacturer may be able to produce the best yarn in the mills is indigenous to the West Indies, and this should be a factor making for success. Appreciation was expressed by Mr. Marsland, of the kindness with which he had been received in the West Indies and of the opportunity that had been given to him to see the experiments in progress at the agricultural stations; in relation to the latter circumstance, he would now be in a position to make the users of cotton, in Lancashire, understand some of the difficulties that are entailed in growing cotton. In regard to manufacture, again, he referred to the waste mentioned by Mr. McConnel, that sometimes occurs in putting the yarn through the machines, saying that Mr. McConnel might also have referred to the fact that the class of workers in cotton-spinning is highly organized, and that when the spinner encountered waste and difficulty in the working up of the yarn, he not only lost the difference between the price of the lint that he had paid for and the purchase value of that which he was able to use, but he had to pay the workers more wages in proportion to the output, so that he was in this way subjected to a further cause of loss. Mr. Marsland hoped that the difficulties would be overcome, eventually, and that as a result of the activities of the British Cotton Growing Association, and the success with which it had met, the West Indies would be greatly benefited.

A paper was then read by Mr. W. ROBSON, Curator of the Botanic Station, Montserrat, entitled The Manner of Cross-pollination of Cotton in Montserrat, which brought forward the following points:—

Recent work with the cotton plots in different parts of the world, has indicated that cross-fertilization is far commoner in the species than is usually supposed, and that the cross-pollination takes place almost exclusively by means of insects. This is important, particularly with reference to the attempt of cotton breeders to obtain pure strains. Two cases, where plants showing ultimately undesirable characters have appeared, seemed to have occurred in Montserrat.

Observations in this island have shown that among the

insects chiefly associated with cotton plants are the Jack Spaniard (*Polistes* sp.), lace-wing flies (*Chrysopa* sp.), lady-birds, grasshoppers, Syrphus or hovering flies. The insects more closely associated with the flowers are Staphyliinid beetles, ants, honey bees, one or more species of small dipterous flies, an unidentified thrips, and a large bee—the female of *Dielis dorsata*; only the last two seem to disseminate pollen to any extent, the thrips chiefly for self-pollination. A description is given of the way in which cross-pollination is effected by the Dielis bee.

A method adopted for determining the extent of cross-pollination in cotton showed that this averages 21 per cent., the limits appearing to be 4 per cent. on a dull showery day and 33 per cent. in bright weather.

Further observations during last year led to the discovery that, in certain localities, two other bees visit the cotton flower frequently: they are *Centrix haemorrhoidalis* and *Megachile* (?) *martindalei*. Their manner of visiting the flower is similar to that of the Dielis bee; they enter it when open. It is probable, however, that they do not distribute pollen as effectively, on account of their slightly smaller size. The amount of cross-pollination by such means must vary greatly in different localities.

A description is given of an experiment that has been devised for finding the extent to which cross-pollination takes place; this is not yet concluded. A suggestion is also made that the degree to which cross-pollination occurs may be determined by observations after planting together yellow-pollened and cream-pollened cotton.

Mr. Robson also presented a note dealing with Sakellarides Cotton in Montserrat.

Mr. A. W. HILL (England) stated, in regard to Mr. Thornton's cross-fertilization experiments with cotton, that he thought that the most important object of such work should be to obtain a fixed type. He laid stress on the value of Mr. Thornton's suggestion that a collection should be made of the varieties of cotton grown, and of the wild cottons, in the different islands, stating that any assistance in the matter that may be required would be rendered by Kew, where there is an assemblage of all the types that had been collected together by Sir. George Watt and described in his book on Indian Cotton. Such work would possess an additional usefulness, in that it would assist in the completion of the general survey of the cotton plants of the world that was being carried out. Mr. Hill paid a tribute to the work that is being done at the Botanic Stations in the West Indies, where lines of special investigation are being followed successfully, amid the distractions of ordinary, routine duties, at the time stating in relation more particularly to cotton, that in his opinion the obtaining of a fixed type of cotton could only be the, result of special efforts made by those whose time would not be occupied by matters pertaining to many other interests.

The PRESIDENT, in closing the discussion, made reference to what had been said by the last speaker with respect to the necessity for specialization by agricultural departments ; this appeared to be the next step, particularly in regard to the policy of the larger among such departments.

Mr. H. A. BALLOU, M.Sc., Entomologist on the Staff of the Imperial Department of Agriculture, followed with a paper on the Cotton Boll Weevil, which drew attention to the following matters :—

The cotton boll weevil (*Anthonomus grandis*, Boh.) does not occur in the British West Indies Previous to 1894, it was recorded from Mexico and Cuba. Since that time it has been known in the United States, having probably crossed the Rio Grande from Mexico some two or three years earlier.

It has gradually, but steadily, spread to the north and east, and has developed into one of the most serious pests ever known to attack any agricultural crop.

Insecticides and natural enemies are alike unable to prevent its spread, which during some seventeen years, has extended about 850 miles in an easterly direction, and about the same distance to the north. Only about 450 miles remained at the end of 1910 to be traversed before this pest should reach the Atlantic Coast.

The loss of cotton as a result of its advent in any district has generally amounted to about one half of the total crop. In the State of Texas alone this has meant a loss in money of $15,000,000 to $22,500,000 in a single year. If the entire cotton belt were affected in a similar manner at one time it would represent a money loss of some $250,000,000.

In 1894, Professor Riley, Entomologist to the United States Department of Agriculture, recommended the State of Texas to prohibit by law the growing of cotton in the area then known to be infested, and in a broad belt outside this. If this had been done, it is probable that the infestation of the cotton belt would have been prevented.

The boll weevil is spread by means of seed-cotton and cotton seed, more than by the flight of the adults. Fumigation of these cannot be relied upon to kill weevils, except in the case of small lots of seed treated with very special care, and then there would always be a doubt as to the result. Many weevils pass alive through the gins.

Wide planting of early maturing varieties, together with special cultural methods and early destruction of all old cotton plants, weeds, etc., in and about cotton fields, afford the greatest relief from this pest.

It is of interest that the spread of the boll weevil has been into the more moist districts of the Gulf Region, rather than into the drier districts to the west.

If the cotton boll weevil should be introduced into the West Indies, it would probably cause the cotton industry to be entirely abandoned in a very few years. No cotton seed or seed-cotton for any purpose should be imported from any American locality outside these islands, from now onward.

On the other hand, if the bcll weevil does not invade these islands, they will probably benefit from the misfortune of the American Sea Island districts, in Carolina, Georgia and Florida, since the reduction of the yields in these localities by anything like one half of the normal amounts would be likely to strengthen the prices for cotton very greatly.

A paper entitled Notes on Certain Cotton Pests, which is abstracted below, was also prepared by Mr. H. A. BALLOU for the Conference:—

The flower-bud maggot, the cotton worm and the black scale are cotton pests of interest, because of certain points in connexion with their occurrence or control.

The flower-bud maggot is the larva of a small fly or midge (*Contarinia gossypii*) of the dipterous family Cecidomyiidae, which first attracted attention at the end of 1907 and the beginning of 1908, by its extremely severe attacks on cotton in Antigua. It is now recorded definitely as occurring in Montserrat.

The eggs are deposited in the tissues of very young flower-buds. The maggots feed on the stamens and pistil, and do injury which causes the buds to drop. The bracts surrounding the bud flare back, and furnish an indication of the attack while the buds are still attached to the plant. As many as forty-three maggots have been counted in one bud.

The maggots leave the bud and pupate in the ground. The flies are extremely small, $\frac{1}{18}$-to $\frac{1}{25}$-inch in length, and difficult to see or capture in the field. The entire life-cycle probably occupies from twenty-four to thirty-one days.

This insect attacks both wild and cultivated cotton, and has been reared from flowers and buds of the wild coffee (*Clerodendron aculeatum*).

The severity of the attacks of this pest had much to do with the great reduction of the area planted with cotton in Antigua. Its occurrence each year seems to be associated with the season of chilly nights and damp atmosphere.

No insecticides have given results in the control of this insect. Early planting, in order that the bolls may be formed before the time for the attack to begin, seems to offer the best means of reducing the loss from this cause.

The cotton worm (*Alabama argillacea*) occurs as a pest in all the cotton-growing islands, except in St. Vincent, where it is controlled entirely by its natural enemies.

During 1909-10 and 1910-11 the cotton worm was very scarce throughout the West Indies. Attacks were more frequent in the latter than in the former season, but not so frequent as in previous years. During the current season (1911-12) the attacks of this insect have been more frequent and of greater severity.

The seasons of scarcity result from the action of natural enemies. Of these, the egg parasites, *Trichogramma pretiosa* and *Telenomus* sp., the internal parasites *Chalcis annulata*,

Tachinid flies, and certain flesh flies, and several predatory insects, are important.

Among the latter are bees and wasps, and a ground beetle. Lizards, toads and birds, especially the Barbados blackbird (*Quiscalus fortirostris*), are also of value in this connexion.

The black scale (*Saissetia nigra*, Nietn.) is of common occurrence in the West Indies. In certain seasons in Barbados it has been the most severe pest of cotton, and in other islands it has been troublesome. Since 1906, however, the insect has been controlled by a parasite to such an extent that in Barbados at least it can hardly be considered a pest of cotton.

This parasite is *Zalophothrix mirum*, a hymenopterous insect, the larvae of which live under the adult scales and devour the eggs. The pupal stage is also passed under the scale, and the adult winged insect emerges by means of a clean-cut, round hole in the scale. The adult is from $\frac{1}{12}$- to $\frac{1}{8}$-inch long, with wings which, when laid flat along the back, do not extend beyond the tip of the abdomen. The general colour is dark-brown The head is reddish-brown and provided with large, dark eyes. The wings are delicate and nearly transparent, those of the first pair being crossed by a broad smoky-brown band near the middle, and near the base of each of these there is a small patch of the same smoky-brown.

The life-history has not been completely worked out. The pupal stage occupies fourteen days; the egg and larval stages somewhat longer, making a probable total of some five or six weeks.

This insect attacks, in addition to the black scale (*S. nigrum*), the oleander scale (*S. oleae*), the brown shield scale (*S. hemisphaericum*), and the barnacle wax scale (*Ceroplastes cirripediformis*).

The following is an abstract of a paper prepared by Mr. J. DE VERTEUIL, Assistant Analyst, Government Laboratory, Trinidad, and entitled Manurial Experiments with Cotton in Tobago:—

Manurial experiments on cotton are being made at Old Grange Estate in Tobago. These experiments are under the control of the Board of Agriculture.

There are six plots of half an acre, including one control plot to which no manure was applied.

The soil is a red loam and the seed from 'Thornton's Hybrid' was planted at a distance of 8 feet by 5 feet during the first week of August 1911. Two weeks later the manures were spread around each plant and lightly hoed in.

The following manures are being used: basic slag, kainit, calcium nitrate, bone meal, sulphate of potash, superphosphate of lime, sulphate of ammonia. The manures are supplied free of cost to the proprietor, but the cost of application as well as the general cost of cultivation are borne by the estate owner.

The PRESIDENT closed the session, and the Conference adjourned for luncheon.

AGRICULTURAL EDUCATION.

The Conference met in session at 12.30 p.m. of the same day (Saturday, January 27) for papers and discussions relating to Agricultural Education. Before these were taken up, with the approval of the PRESIDENT, Lieut-Colonel J. H. COLLENS (Trinidad), adverting to the booklet, Insect Pests of the Lesser Antilles, by Mr. H. A. Ballou, M.Sc., thought it deserved something more than passing notice. They in Trinidad, he was sure, would find the work very valuable, interesting and useful, and as copies had been distributed among numbers of the Conference, he thought that as a Conference, they should take more notice of it by placing on record their appreciation of it.

The PRESIDENT said the handbook had been prepared by Mr. Ballou as a Conference paper, but obviously it did not admit of being treated as an ordinary paper, for it is intended as a work of reference for use in the future, for which purpose it promises to be valuable. He was pleased that Colonel Collens had sounded a note of appreciation of the rather bulky work, and regretted that Mr. Ballou was not present to hear the encomiums passed on it.

Lieut-Colonel COLLENS: 'It is one of the most important papers of the Conference.'

The special business of the session was then commenced by the reading of a paper entitled Agricultural Education in Grenada, with Special Reference to the Secondary School for Boys, by Mr. D. HEDOG JONES, B.A., B.Sc., Head Master, Grenada Boys' Secondary School. It dealt with the following points:—

The paper commences by pointing out that agricultural education, in its various aspects, has received very thorough consideration on the part of authorities in the West Indies, during the last ten years, and refers to the work of the Imperial Department of Agriculture in this respect. It then speaks of the attempts that have been made to introduce rural teaching into Grenada elementary schools, and states that the main purpose of the paper is to show how the re-constituted secondary school in that island would be made to bear relationship to the island in general and to the agricultural community in particular.

Reasons are adduced for the failure of attempts to introduce nature study as a useful subject, into Grenada elementary schools. This has been due to the lack of requisite and sympathetic knowledge on the part of teachers in such schools —a condition that has arisen partly from the fact that the lectures given to such teachers in the earlier years were not followed up by further courses. The enthusiasm first engendered soon waned, and a few years later it was proposed that the grants should be curtailed in the case of schools that did not use their garden plots. The matter began to be serious toward 1907, and since that time the gardens have been literally abandoned.

The point is made that the foremost educational need of Grenada, at present, is the proper correlation of all the activities in agricultural education throughout the island. After giving some general consideration as to the meaning of education, the paper refers to the inexpediency of teaching agriculture, rather than nature study, in elementary schools. This portion is succeeded by a broad account of the Grenada Grammar School, since its opening in 1885, and of its recent reorganization. The intention is that the teaching of agriculture in it shall be brought into line with the requirements of elementary schools in regard to nature study, and that this teaching shall form a strong part of its curriculum—without detriment, however, to the claims of other subjects. An account is given of the arrangements that have been made in the school, in relation to the work, and it is shown that, with a fuller equipment of scientific instruments, these will suffice for a time. In regard to the science teaching that is to be given, attention is attracted to the importance of drawing as a useful subject, and to the necessity for a school museum, to aid in the work. It is intended that the school shall possess a school garden, and the Superintendent of Agriculture has kindly placed a plot of ground in the Botanic Gardens at its disposal for the purpose. There is no definite scheme of agricultural scholarships, except for the existence of the usual minor open Government Scholarships. Suggestions for such a scheme are, however, under consideration.

It is pointed out that specialization will not take place, in regard to the agricultural work in the Grammar School, until the higher forms are reached. Reference is made to the Cadet System of the Imperial Department of Agriculture, and proposals by the Superintendent of Agriculture, in relation to the adoption of this, in Grenada, are detailed.

The paper concludes with a review of the reasons that can be adduced for the recognition of the necessity of the improvement of West Indian agriculture, particularly in Grenada.

Mr. W. G. FREEMAN, B.Sc., A.R.C.S., F.L.S., followed with a paper dealing with the Report of the Trinidad Committee on Agricultural Education, which was just being issued. An account of this is reproduced below, from the *Port-of-Spain Gazette* for January 28, 1912:—

A short time ago it was thought advisable to appoint in Trinidad a Committee to consider and bring into harmony the lines of work which had already been carried on in agricultural education. It was also proposed that the report of that committee should be put before this Conference in the hope that, by the varied experience of its members from other colonies, Trinidad would be helped to solve some of her difficulties. The Committee was representative of agricultural and educational interests and had prepared a provisional report for the Conference. Of course, most of the people here were different from those of the other colonies, and their interests more diverse. The subject was not new to Trinidad, having been first proposed in 1890, actually introduced into the primary schools about 1900 and some years later taken up actively in

secondary schools. In the elementary schools, agriculture is a compulsory subject for boys. Lectures are given by travelling agricultural instructors, and the school teachers are qualified by examination to teach the subject. School gardens are cultivated; and it is now proposed that the fruit and vegetables grown therein should be sold, the proceeds being divided into three, for managers, teachers and boys. It is recommended that the sum of £10 be given either by the Government or the Board of Agriculture for awards in prizes for school work. As to secondary education, it is a compulsory subject for boys in Form VI. of the Colleges, for the Cambridge Senior Local Examination. It is considered by the Committee that agricultural science should not be a compulsory subject in the Colleges, and that the time at present devoted to its tuition is not sufficient. If it were optional, boys who have a taste for it would have more time to devote to it. Then, there is an agricultural pupil's scheme in contemplation. There is no trouble in the supply of overseers and drivers, but there is great difficulty in obtaining good ones. A pupils' scheme is recommended to improve the standard, and the Government or the Board will be asked to give two exhibitions of £25 per annum tenable for three years to boys under fourteen or fifteen years of age, by examination. At the expiration of training, the pupil will hold some junior post in the Agricultural Department. An examination in practical agriculture in connexion with home reading courses was started by the Department of Agriculture last year, and suggestions are made for its practical improvement. The principal point upon which the Committee desired help was as to the youngest age at which pupils should come under the agricultural scheme. If a boy left school about fourteen and studied hard for two or three years, he wonld be qualified at about seventeen for work as a driver on an estate. Practical planters suggest between seventeen and eighteen years as the age to begin study. He had there a list of thirty-one cadets trained at the local Botanic Gardens between 1900 and 1909, thereby showing that the proposed system is not altogether new. Of that number, six are now managers of estates, three overseers, five clerks, one a surveyor, one an overseer in the Public Works Department, five miscellaneous and nine are not known.

In the discussion that followed the reading of these papers, Dr. A. FREDHOLM (Trinidad) gave information as to the age at which agricultural education is taken up in various countries in Europe. Mr. A. LEECHMAN (British Guiana) referred to the distinction that exists between the practical side of agricultural education and the practical side of a boy's nature. He did not agree with the teaching of agriculture in elementary schools; this should be a matter for agricultural schools. The Rev. Dr. MORTON (Trinidad) regarded the subject entirely from a practical point of view, and thought that some agriculture could be taught, and properly taught, in the elementary schools and school gardens. He laid stress on the importance of the practical work in such gardens, together with nature study. He did not

agree, however, with the dividing of the proceeds from the gardens among the school managers, the teachers and the pupils: a better method was to provide the tools and to make the schools responsible for their care and safe custody. Lastly, he referred to the influence of enthusiasm on the part of the teachers, and to the value of sympathy, in discharging their duties, on that of inspectors. On a point of explanation, Mr. A. LEECHMAN expressed his advocation of the development of the practical side of the mind of the pupil, and his support of the school garden movement. In regard to the provision of schools of a technical nature, to which reference had been made, Mr. J. R. BOVELL (Barbados) enquired as to the way in which these would be reached by the pupil, and made reference to the difficulty of the provision of sufficient of these for the elementary schools, if nearly all the pupils were to be sent to them after attaining theoretical knowledge in the elementary schools. Mr. S. SIMPSON (England) referred to the similar conditions in England, and stated that he thought that the recommendations in the Report of the Trinidad Committee on Agricultural Education might have gone much further. He also described the methods of agricultural training in Egypt, where he had had experience as Vice-President of an agricultural college, and thought that the time had come for the establishment of a similar institution in the West Indies. The Hon. D. S. DE FREITAS (Grenada) referred to the importance of agriculture in the West Indies, and to the aversion to it that is growing among the younger generation What he had just heard led him to the opinion that it was one of the most important subjects for discussion at the Conference, and he was confirmed in that opinion by the evidence of the inadequacy of the present efforts to teach agriculture in the West Indies, that had been brought forward. Greater discrimination was required in relation to the kind of agricultural teaching that is given in secondary and in elementary schools; there should also be distinction between the teaching in country schools and that in town schools. As regards the age of agricultural pupils, he thought that, after a boy had reached the age of fourteen years, if he showed any tendency toward agricultural subjects, he should be allowed to specialize in those subjects.

Continuing the discussion, Professor J. B. HARRISON (British Guiana) described the early steps that were taken, in Barbados, in connexion with agricultural education, and referred to the difficulties that are being experienced generally in regard to this subject, particularly in British Guiana. In this Colony, proof that the Government realizes the importance of agriculture in education has been afforded by the appointment of the Director of Agriculture to be Chairman of the Board of Education. He proceeded to give an account of the school gardens in Demerara, stating that the number at the present time in that country is 106. These had not been found entirely to fulfil the purpose for which they were intended, and had been supplemented by a system of model gardens, nine or ten of which had been established at different centres to supply the needs of an area of about 150 square miles. In giving a description of the

organization and procedure in connexion with the system of model gardens, the speaker mentioned that the number of attendances during the visits of the Superintendent of Model Gardens, in 1910, had been 21,340, and stated that the annual cost of the scheme was $2,389, made up as follows: salaries of the Superintendent and assistants, $1,282; maintenance of two model gardens in Georgetown, $336; maintenance of model gardens in the country districts, $771. It was intended to make a further development of the model gardens scheme, but certain difficulties arose in regard to obtaining suitable men for the purpose of supervision. The usefulness of the Superintendent of Model Gardens was extended by his availability to visit any school which may requisition his services, which are all the more valuable from the fact that the holder of the appointment has acquired by means of the system, a much wider scope and experience than any one schoolmaster could get. A general result of the establishment of model gardens had been that the objections to work in such places, evinced at first, had disappeared both on the part of parents and children. In regard to agricultural schools, a Commission, of which he is the Chairman, had been appointed, and was in favour of the establishment of such institution; it was proposed to establish one at Suddie, and the cost was estimated at $20,000 to $30,000. Lastly, Professor HARRISON said that he felt it an absolute necessity that the West Indies should possess an agricultural college where the workings of nature could be studied under tropical conditions, and that nothing would give him greater pleasure than the establishment of an institution of the kind for the benefit of the West Indian colonies.

In reply to The PRESIDENT, Professor HARRISON explained that it was hoped to include two classes in the proposed agricultural school: the class that would be an overseer or head man, and the class that would proceed further and be available for managerships. Mr. D. CAMPBELL (Jamaica) gave information concerning the working of the Jamaica Farm School, the system of school gardens, and the work of the agricultural instructors, in the island. Teachers were assisted in regard to the instruction in school gardens by the fact that a certain proportion of them was called up, every year, for practical lessons in the subject He also drew attention to the work of the Jamaica Agricultural Society, stating that there are now ninety-one branch societies throughout the island, within ten miles from one another, their meetings being attended for the greater part by the peasantry, and the prospects of the work of such branch societies were considered to be excellent. Monsignor C. B. DE MARTINI (Trinidad). who was permitted to join in the discussion, laid stress on the necessity for the inclusion of a large amount of practical work in agricultural instruction. Lastly, the Hon. G. S. SETON BROWNE (Grenada) gave attention to experience that had been met with in regard to agricultural teaching in elementary schools, in Grenada, saying that the difficulties were of much the same nature as those in other colonies. This speaker also referred to the need of agricultural federation between the West Indian colonies, and the way in which such meetings as agricultural conferences may help to make this possible.

A paper entitled The Need for Higher Agricultural Education in the West Indies, was then read by Dr. A. FREDHOLM (Trinidad); this gave attention to the following matters:—

While on one hand statistics show that agriculture is the principal source of wealth to the West Indies and furnishes employment for the bulk of the population, yet, it is on the other admitted that our agricultural operations are conducted in the crudest manner. The reason for this would appear to be attributable to lack of training among our agriculturists. In other parts of the world the necessity for a technical education of all classes of agriculturists has been recognized, and agricultural schools and colleges have been established. The former turn out men, such as overseers and foremen, well fitted for subordinate posts; while from the latter are graduated men qualified to occupy the responsible positions of managers and owners. The need for trained men has been felt in the West Indies, and attempts have been made to supply it by adding educational activities to the other functions of the Departments of Agriculture, by incorporating nature studies in the curriculum of public schools, and by the establishment of home reading courses. These modes of disseminating agricultural education are not far-reaching enough, nor do they admit of the thorough training supplied by special agricultural educational institutions. Establishments of that kind located abroad are not suited to the needs of the West Indian agriculturist, because they cannot furnish such training as is specially applicable to agricultural conditions here. Schools and colleges for the training of West Indian agriculturists must be located in the West Indies, in order to provide the specific training required to meet West Indian conditions.

That the inhabitants of the West Indies eagerly avail themselves of educational facilities is a well-established fact. Professional life appeals to them, especially when it is associated with financial gain. A careful comparison between the earning capacities of the medical and legal professions, of the civil service, of mercantile careers, and of artisans, and the earning capacities of the agricultural profession will prove that agriculture is as remunerative, in the West Indies, as are other professions or vocations. Agricultural training is, as a rule, less costly than are trainings for other professions. The manner in which agricultural educational institutions are supported varies somewhat in different countries; general revenue, special taxation and land grants, singly or in combination, are the usual sources from which funds are obtained.

It should be observed that imparting agricultural education is the principal aim of agricultural schools and colleges, and that such labours as agricultural research work and the enactment of agricultural legislation are delegated to Departments of Agriculture and to Boards of Agriculture. In some instances it has been found convenient to add research work to the educational functions of schools and colleges, thus effecting a saving of money.

In the West Indies we have now the Imperial Department of Agriculture, well equipped, with an efficient staff, doing

mainly research work, under which term is here included experimental work. In the smaller islands this Department partly maintains, and to a certain extent controls, stations mostly engaged in experimental work. In some colonies, Departments or Boards of Agriculture exist which employ corps of officers also conducting investigations – nowhere are agricultural schools or colleges to be found. It would seem that only some additions to, and minor alterations and re-adjustments of, our present agricultural institutions, would be required in order to provide for agricultural education on modern lines. For each colony to maintain an agricultural college would probably be a waste of money, but one or two of the larger colonies could well afford to establish such institutions, devoting part of the revenue, now used by the Departments and Boards of Agriculture for research and experimental work, to educational purposes. To continue investigations in matters pertaining to agriculture is absolutely necessary, and experiment stations must be maintained for the conduct of this line of work. In order to secure co-operation in research and experimental work and avoid overlapping, it would seem desirable that all stations should be under one control. To exercise such supervision the Imperial Department would be eminently fitted, and it might be possible that in such a case the Imperial Government, if approached, could see its way to grant a subsidy sufficient for an experiment station in colonies devoting their revenue to agricultural education of collegiate grade. The botanic and other stations now established in the smaller islands could be converted into agricultural schools. The cost of maintenance of such institutions when run on proper lines is not great, as they are to a considerable extent self-sustaining—in some cases entirely so. The schools could be supported from the revenue of the islands in which they were located, and the funds now contributed by the Imperial Government would continue to support the experiment stations.

Higher agricultural education could not fail to exert far-reaching effects in the West Indies. It would be of great economic consequence, because it would provide a trained body of men to conduct the main industry of the colonies; our youths would have opened to them a new field in which their energy and ambition could be most usefully employed, both for the good of their own future and for the good of the British Empire. All classes of agriculturists would benefit—trained proprietors, managers and overseers would tend to increase the skill of the labourers; in the agricultural schools the opportunity would be given to the peasant to acquire an education suited to his demands, and at a cost within his means.

The need in the West Indies for agricultural education of a higher grade has often been admitted and the subject so frequently discussed that it would seem that little now remains to be done, except to take definite action on the many suggestions which have been made from time to time. 'The consideration of means for advancing the material prosperity of these Colonies' is the object of these Conferences. May not this, the eighth West Indian Agricultural Conference, devote

some of its energy to procuring for these agricultural colonies higher agricultural education?

This was followed by a paper entitled A Lectureship in Tropical Agriculture, by Mr. S. SIMPSON, B.Sc., M.R.A.S.E., N.D.A., formerly Science Lecturer in Agriculture to the Egyptian Government Agricultural College, which is abstracted as follows:—

Reference is made to the Departmental Committee appointed in 1908 by the Board of Agriculture and Fisheries to enquire into, and report upon, the subject of Agricultural Education in England and Wales, and to the far-reaching results that will follow the work, on the basis advocated by this Committee, that is being carried out already in Great Britain. This Committee appears to have been impressed by the work that was being conducted by the Agricultural Departments at the University of Cambridge and at Edinburgh University, and recorded in consequence its opinion that universities, in making provision for the training of agricultural experts, are doing not only a national but an Imperial work: further, one of the principal recommendations of the Committee was to the effect that much assistance toward the provision of agricultural experts for the development of tropical and sub-tropical colonies would be given if a readership or lectureship on tropical agriculture was established at one or more British Universities. The paper goes on to show how such a scheme would prove itself useful, and the writer makes the suggestion that the Imperial College of Science, South Kensington, should be the first place at which such a lectureship may be instituted. After giving a criticism of the past lack of means that has existed, for training men to supervise and conduct agricultural operations in the overseas possessions, and drawing attention to the wastage and loss that have occurred through neglect in the matter, the writer expresses himself as follows:—

'The world's demands are rapidly increasing for every kind of produce and with this increasing demand there is a strong tendency for prices to rise permanently to a higher level.

'With our tremendous interests involved every effort should be made to spread knowledge concerning the cultivation of these various crops which mean so much for mankind in general and to Great Britain with its ever expanding commerce in particular.

'It will be a small step forward when something is done to provide for the training of men who are entering the ranks of those practically engaged in the cultivation of the various crops of the world.'

Mr. NORMAN LAMONT (Trinidad) stated that he happened to be the member of the Departmental Committee of the Board of Agriculture in England who was responsible for the paragraph in the report to which reference had been made specially by Mr. Simpson, and that it was through his efforts that the subject of tropical agriculture, which was not properly within the scope of the enquiry, was included. He need not say how much satisfaction it would give to the other

eleven members of the Committee, and to himself personally, if a resolution was passed supporting the recommendations contained in the report.

The list of papers to be taken at this session included The Cadet System in Antigua and St. Kitts, by Mr. H. A. TEMPANY, B.Sc., Superintendent of Agriculture for the Leeward Islands, which was published in the *West Indian Bulletin*, Vol. XII, p. 20 and Peasant Agriculture in Grenada: Suggestions for its Control and Improvement, by Mr. G. G. AUCHINLECK, B.Sc., Superintendent of Agriculture, Grenada. For want of time, these were taken as read. An abstract of the latter-mentioned paper is as follows:—

This paper commences by drawing attention to the extent to which peasant ownership continues to exist in the Colony of Grenada with Carriacou, notwithstanding the great value of cacao to the former island and the fertility of the land in the latter. It then proceeds to give statistics as to the land actually owned by peasants in the Colony, and a consideration of the matter affords the following figures:—

CLASS OF HOLDINGS.	CARRIACOU, acres.	GRENADA, acres.
10 acres and under	1,700	10,300
Over 10 acres	6,000	64,200
Forest	300	2,500
	8,000	77,000

A calculation is made of the proportion existing between the total area of small peasant holdings and that of holdings over 10 acres, and figures obtained which it is suggested may be termed the Ratio of Peasant Ownership; in Grenada this is 1:6·2, and in Carriacou, 1:3·5; so that for every acre owned by peasants, there are in Grenada 6·2 acres, and in Carriacou 3·5 acres, owned by large proprietors.

In estimating the comparative efficiency of small holdings, it is concluded that about 5,000 bags of cacao are produced yearly from this source, the value being about £20,000. Other considerations are brought forward (though the whole matter is evidently one of approximation) to show that the following particulars of peasant products in Grenada and Carriacou may be compiled provisionally: cacao exported £10,000, cotton and cotton seed £2,000, sugar £2,400, foodstuffs £4,000, making a total value of £18,400. When this is compared with the difference between it and the whole value of the foodstuffs and marketable agricultural products exported from Grenada and Carriacou in 1909, namely £260,000, a new term is obtained that may be called the Monetary Ratio of Peasant Production; the value of this is 1:18·2, or it may be said that for every £1 produced by peasants, £18·2 are returned from larger estates. It is well recognized that the difference in kind of peasant crops, from those on estates, prevents the former from ever being as valuable. The ratio given may possibly be high, being based on approximation; nevertheless, even if it is brought as low as 1: 10, a large discrepancy is shown between the amount of peasant ownership and that of peasant production.

The paper goes on to deal with the defects in methods of peasant cultivation and the causes of inefficiency. It is suggested that the effective control of small holdings may be brought about for the following reasons: (a) for increasing the wealth of the Colony: (b) for the improvement of conditions of life and for increasing the efficiency of labour; (c) for protecting efficiently handled cultivations from the danger of being attacked by diseases neglected on small holdings.

The fact that a large area of land remains for cultivation in the Colony, and the circumstance that large sums of money are expended annually in other islands for foodstuffs that could be raised locally, lead to a realization of the necessity for aid and advisory control by some stable centralizing body. The imports into the Colony of products that could be raised by peasants, possessed the value in 1910 of £11,428; these included fresh fruit to the value of £80, whereas nine years ago, Grenada exported, on the contrary, fresh fruit to the value of over £800. Much of the present state of affairs arises from the undue emphasizing of the value of cacao; whereby a tendency has ensued to neglect lands that are unsuitable for this crop, instead of employing them to raise other products.

The devices that have been suggested for the replacement of compulsory labour have comprised the following: (a) Measures of Inducement, including prize-holdings competitions and prizes for vegetables in the market; (b) Measures of Capitalization, including land settlements and miscellaneous measures such as the erection of cotton ginneries and sugar-cane mills for the peasants; (c) Measures of Instruction, which have comprised the giving of agricultural instruction in connexion with the Prize-holdings Scheme and land settlement, the work being done by the Agricultural Instructor under the Agricultural Department. Details are afforded of those different measures, and an account is presented which deals with their inadequacy and includes suggestions for the future.

The paper closes with the reminder: 'Attempts to increase the efficiency of agricultural methods among peasants in small tropical countries must invariably be expensive. Education, the ordinary incentive of competition, and ability to raise capital are all reduced to a minimum and all need attention in any comprehensive scheme. The question as to the advisability of control and help must certainly be answered in the affirmative from the ethical point of view, and probably also from the point of view of political economy.'

The PRESIDENT, in closing the session, announced the titles of papers that would be read during the excursion, to take place that afternoon, to the Government Stock Farm and St Augustine Estate.

As has been indicated, the Conference Delegates, and others who were interested, paid a visit to St. Augustine Estate and the Government Stock Farm, St. Joseph, in the afternoon of the same day (Saturday, January 27). The excursion was made on the invitation of Professor P. CARMODY, F.I.C., F.C.S., Director of Agriculture, Trinidad. Advantage was taken for the presentation of two papers, the first of which was entitled

The Profitable Breeding of Horses, by Mr. J. L. SHANNON, D.V.M. (Barbados), and dealt with the following points:—

The purpose of this paper is to commend the American carriage horse to West Indian horse breeders for the purpose of raising horses for export and obtaining animals more suited to the particular work in the West Indies. The type of carriage horse recommended is that which is being developed by the United States Department of Agriculture in co-operation with the Fort Collins Experiment Station, Colorado. (See the Twenty-fourth Annual Report of the Bureau of Animal Industry of the United States Department of Agriculture, 1907.)

Among the reasons advocated for the adoption of the breed is that given by G. M. Rommel, Animal Husbandman of the United States Bureau of Animal Industry. It is as follows: 'That carriage horses are as a rule the most valuable class on the market; that as a result of the strong demand the supply was gradually diminishing, and that notwithstanding all the importations of the carriage type from abroad, the preferred horse was the American horse.'

An account is given of the history of the breed, succeeded by the following suggestions in connexion with work in the West Indies: (1) it seems far more profitable to breed horses which could be placed at a high price on the New York market than to produce animals for use on the race-course: (2) experience in Kentucky has shown that it is better to breed horses for type than for speed; (3) the adoption of such a system would lead to the production of a certain number of horses not quite up to the standard of the New York market, but superior to the present animals, and these could be used locally; (4) the suggestion is made that the work should be carried out by co-operation between the Imperial Department of Agriculture and the various Government Stock Farms in the West Indies; (5) co-operation in the matter has already shown its value in the United States; (6) the breeding of race-horses should be a matter for private individuals alone; (7) the work requires undivided attention for a series of years, and there must be a rigid elimination of indiscriminate crossing of breeds.

The other paper was entitled Milking Capacities of the Trinidad Government Farm Cows, by H. S. SHREWSBURY, F.I.C., Assistant Analyst, Government Laboratory, Trinidad, and the information in this may be summarized as follows:—

The investigation was carried out, with the co-operation of Mr. J. McInroy, manager of the Trinidad Government Farm and St. Augustine Estate, on cows of the following breeds: half-bred Zebu, half-bred Red Poll, half bred Guernsey (including one pure-bred Guernsey cow), half-bred Shorthorn, and Holstein. The comparison of the results cannot be made very rigid, because of the differing numbers of cows in the various classes; as far as the comparison goes, however, the half-bred Zebu seems to be the best breed. Among the animals belonging to this there were included cows giving the best quality of milk and also the largest yields of 'very good quality' milk; that is milk containing at least 3·5 per cent. of fat. The half-

bred Zebus also supplied the cow giving the poorest yields and poorest quality of milk; 'there appears however, a possibility of producing very fine milking animals by selection from this breed.'

CONFERENCE DINNER.

The members of the West Indian Agricultural Conference dined together at Queen's Park Hotel on the evening of Saturday, January 27, at 8 o'clock. The arrangements for the dinner were in the hands of a Committee appointed for the purpose, consisting of Sir Frederick J. Clarke, K.C.M.G., Mr. W. N. Sands and Mr. H. A. TEMPANY (Honorary Secretary).

The President of the Conference (Dr. FRANCIS WATTS, C.M.G.) occupied the Chair. Covers were laid for one hundred and twenty. In addition to the members of the Conference, there was a large number of guests, including the following: His Excellency Sir G. RUTHVEN LE HUNTE, G.C.M.G., Governor, and A.D.C.; the Hon. S. W. KNAGGS, C.M.G, Colonial Secretary; the Hon. W. GOLLAN, K.C., Attorney General; the Hon. R. G. Burke, Auditor General; Lieut.-Col. G. D. SWAIN, Inspector General of Constabulary; the Hon. R. AUCHER WARNER, K.C., Solicitor General; the Hon. H. L. CLARE, Surgeon General; the Hon. D. SLYNE, Receiver General; the Hon. H. B. WALCOTT, Collector of Customs; the Hon. Sir G. TOWNSEND FENWICK, K.C.M.G.; the Hon. THOMAS COCHRANE, also the representatives, at the Conference, of Trinidad and Tobago; and others.

Dinner over,

Dr. WATTS rose and proposed the toast of 'The King', which was drunk with the accustomed honours.

Dr. WATTS next rose and said: Your Excellency, My Lord and Gentlemen,—It is my pleasant duty to propose the toast of 'Trinidad and Tobago'. (Applause.) Pleasant as that duty is, the sense of responsibility that rests upon me is almost overwhelming, for in presenting that toast it devolves upon me to express on your behalf, the sense of appreciation which we feel with regard to the magnificent manner in which we have been entertained by this Colony. (Applause.) I feel that, however eloquently I might speak, I should quite inadequately express all that we feel. In my remarks at the opening of the Conference I stated with all confidence that I felt perfectly sure that the appreciation which the delegates would feel of the manner in which they would be received and entertained by the Colony of Trinidad would grow from day to day. (Hear, hear.) Several days have gone by since the opening, and I feel certain that in your name I voice what I then ventured to state in anticipation, when I say that your appreciation has grown from day to day, and to-night it stands at a very high pitch. When one considers how much trouble, forethought, care and kindness have been bestowed upon us by everyone, from His Excellency the Governor, the Colonial Secretary; from the Department of Agriculture with its various officers—Professor Carmody who has recently returned (applause) with his able

lieutenant acting in his absence in the preparatory arrangements for the Conference—Mr. Freeman (applause); the officers of the Board of Agriculture—Mr. Rorer, Mr. Urich—all of whom have energetically striven to do all they could to further our work and our pleasure—when one thinks of how every Club in the community practically has thrown its doors open to us and invited us to receive its hospitality during our stay here; how so many organizations in the country—the Railway, the Tramway Company, the Telephone Company, and I must mention with high appreciation the efforts of the Royal Mail Company (cheers)—associated themselves with the Colony of Trinidad; how very great private hospitality has been lavished upon the members of the Conference individually and on the Conference as a whole; how the Hon. Thomas Cochrane, yesterday, at great trouble and pains took us on one of the most memorable expeditions which any Conference could have, namely the excursion to Point Fortin (applause);—then I am sure that it would be difficult for me to give full and adequate expression to the high appreciation we feel. (Applause.) All of us, with the exception of British Guiana, practically come from Colonies which are smaller in area than Trinidad. Trinidad offers to those delegates, so coming, a picture of West Indian prosperity and a possibility of advancement which are highly encouraging to us, because we can look upon her as something in the West Indies which stands for prosperity and something which is flourishing. (Cheers.) Sir Charles Lucas, of whom every one will think with the deepest respect (applause), and who has recently retired from his labours at the Colonial Office, said that, at one time not very far removed, one looked forward to the possible prosperity of the West Indies—a thing that may be looked upon now as having to a large extent arrived. Trinidad, of all the Colonies perhaps, exemplifies the revival of prosperity to the West Indies more than any other West Indian Colony. (Cheers.) But Trinidad is only at the threshold of its prosperity; Trinidad has a long way yet to go; much more is to be done to realize the full measure of prosperity that awaits it. (Applause.) With such a prospect before the Colony, we can appreciate fully the kindness and generosity with which the larger of the West Indian group extends a welcome to the smaller sisters which surround it, holding out to them the hand of fellowship as it has done and as it will do as time goes on, and giving us the hope of a union of the West Indies—a union which I feel sure will come more through agricultural methods than through any other means we may suggest. The agricultural union of the West Indies is the most promising feature of the idea of federation which can be held out to us, and it no doubt centres very largely in the prosperity of the magnificent island of Trinidad, whose prosperity we most cordially wish for. In conclusion, Your Excellency and Gentlemen, I ask you to drink the toast of the prosperity of Trinidad and Tobago, coupled with our heartfelt appreciation and thanks for all the kindness that has been lavished upon us, and all that has been done to make this Conference one of the most successful of the West Indian Agricultural Conferences. (Great applause.)

The toast was drunk with much enthusiasm.

His Excellency the Governor (who on rising to respond was received with cheers) said: Mr. President, My Lord, Your Honour and Gentlemen—I have been asked at very short notice to respond to the toast of 'Trinidad and Tobago', and I feel it a high honour and privilege to do so. I have to thank you, Mr. President, and all who joined with you in the kind words and expressions you have used with reference to your stay amongst us. If your pleasure is anything as deep as ours, it must be very great. (Cheers.) I am extremely glad that you had an opportunity of seeing our beautiful and, as the President said, our prosperous Colony. We have been very fortunate in having had fine weather. It would have been much more difficult to have shown you what you have seen if we had had weather which we sometimes have in Trinidad. The weather has favoured the Conference and has certainly added very greatly to the facility with which we have been able to carry out the programme and the expeditions that were arranged for. I think you will agree that Trinidad is an object-lesson in many ways. We are trying as you see in every way to push agriculture; to help not only the big planter by our officers and specialists who are always engaged in finding out what diseases exist, many of them not known to us before: and when they discover them then to find out a remedy for them. But it is not only for the big planters, who have to put their hands into their pockets themselves to engage the specialist sometimes for months here to study a particular disease, but also for our peasant proprietors. The latter are equally the object of care to us as are the big planters. We have our agricultural instructors travelling constantly through the Colony helping the small man as well as they can. Our cane-farming is now attaining to very large figures, and the impetus that has been given to cane farmers and cacao cultivation by the Board of Agriculture, and the great interest taken in these by the Agricultural Society, is doing a great deal of good which will bear immense fruit later on. I think you were pleased when you saw at the Experiment Station how the Government had set to work there (cheers), beginning at the right end, by teaching people to find out what is the best thing to grow and the best way to grow it. Trinidad is prospering in many directions very well, and is going ahead so fast, that it is almost impossible for the Government to keep pace with it and meet all its requirements without great sacrifice. However, that is a healthy sign, and the Governor who comes here fifteen years hence will have a very easy task compared to what the Governor of the present day has, chiefly because the Colony is going so fast that we cannot keep up the pace. I believe, as the President said, we are only on the threshold of our real prosperity. It would not be proper for me to indulge in prophecies as to what may be the future of our Oil Industry, but I for one have no doubt as to the future prosperity of the Oil Industry of Trinidad (Cheers.)

I wish you had an opportunity of going to see Tobago. Tobago is absolutely different from Trinidad but is also bright, beautiful and progressive, and like Trinidad, its history is an interesting one; there is hardly a spot in it that has not an

historical interest, at one time of very great value to the West Indies Then it fell back and got as low as any other island did, but it is now rising up from its troubles and getting again into clear sunshine. I myself have had the good fortune of seeing, during the three years I have been here the wonderful change in Tobago, and it is going ahead fast. We have some energetic planters there, especially in the Windward district; we have one to whom we owe a great deal for the energy in regard to cotton in the other parts of the island. I will not mention names, but Mr. Thomas Thornton will know the gentleman whom I mean. (Cheers.) I may also say that they have very energetic Government Officers there, and altogether, I am very happy about Tobago, and should not like it to be left out; and I hope the President will excuse me if I supplement something which he meant to say. (Applause.)

HIS EXCELLENCY (continuing): Now, gentlemen, I am also charged with another duty, and that is to propose the toast of 'The Imperial Department of Agriculture for the West Indies'. (Applause.) We all know very well what the Imperial Department of Agriculture has done for the West Indies. If anyone does not know the work which that Department has done and is doing, may I commend him to a number of the *West Indian Bulletin**, which has been lately issued, in which the whole history and work of the Imperial Department of Agriculture in every one of the West Indian Islands is set out in detail. Short of that number of the Bulletin, I do not think it is the least use my trying to say anything about it. If you want to know, there is the book, and you will find the fullest information; and the more you read it, the more you will appreciate its splendid work and the great debt that the West Indies owe to the Imperial Department of Agriculture. (Cheers.) Here in Trinidad we work in complete harmony with the Department. The Department has no official *locus standi* here; we work independently of it, but we exchange opinions, and every officer of the Imperial Department of Agriculture is always more than welcome when he comes to Trinidad. (Cheers.) We are bound to acknowledge the splendid work the Department has done and we are only too glad to see the Imperial Commissioner or any one of his officers whenever they come here; and I have no doubt that the interchange of information and personal knowledge of each other between the expert officers and specialists of the Imperial Department and the local Department, will tend to the great good of agriculture in the West Indies. I quite agree with Dr. Watts that one of the greatest uses of this Conference, short as it has been, is the opportunity that it gives for the interchange of opinions, and the oftener people interested in every phase in agriculture can be brought together from the different West Indian Colonies, and not only from the West Indies but also from England, and from Surinam (the delegates from which places, I hope, will take home very happy recollections of their visit here)—the oftener we meet and discuss matters and the more we have a personal knowledge of each other, so much the more will the value of these Con-

*Vol. XI, No. 4, November 1911. [Ed., *W.I.B.*]

ferences increase. I ask you to drink to the health of the Imperial Department of Agriculture, coupled with the name of the President, Dr. Watts. (Applause.)

The toast was drunk with the greatest enthusiasm,

Dr. Watts, in responding said: Your Excellency, Your Honour, and Gentlemen—It is extremely gratifying that you should receive, with so much approval, the toast of the Imperial Department of Agriculture: it is extremely gratifying to me, and I am sure it will be equally gratifying to all those who have been associated with the work, from Sir Daniel Morris who was instrumental in laying the foundation of the work of the Department and officers of the Department who were associated with him in that work, and to every one of us connected with it. The work of the Imperial Department of Agriuclture has passed through many phases. The Department was founded, as you are aware, at a time when West Indian prosperity was almost at its lowest level. It was founded in the hope that it would do something to afford amelioration to the state of affairs that existed then, and restore those conditions which Sir Charles Lucas, to whom I have already referred, said he hoped would return to the West Indian Colonies. In those earlier days, some of the administrative work of the Department was easier than it is now, for at the time there was attached to the Department the distribution of conr siderable sums of money to most of the islands. When an officer of the Government is charged with the disbursement of moneys, his task is not altogether difficult. I, unfortunately, stepped into the position when the disbursement of money was no longer assigned as a function of the Department, and my somewhat invidious and somewhat difficult task was to induce the Governments, which had established in their midst some organizations with the aid of Imperial money, to see the desirability of readily and willingly saddling themselves with the burden of raising the funds to continue that work. That, Gentlemen, is an extremely different matter from putting one's hand into the Imperial purse and finding the means with which to do the work. Fortunately, however, in most cases—practically in all cases—with a little care, a little persuasion and a little patience, the work goes on happily and well. The larger Colonies—Trinidad among them—did not need much Imperial money and did not receive much—just a little to give a fillip to the work; but very considerable amounts of money were spent in the other Colonies. The removal of that money and the adjustment of the wheels of Government have given me many an anxious moment and a great deal of thought. Fortunately, I think, things are going happily and smoothly, and I hope that all will continue well.

It is perhaps necessary, owing to the changes that have taken place, that one should say something as to where the Department now stands. The Imperial Department of Agriculture, as far as Trinidad, British Guiana, Jamaica, and recently, by the turn of events, Barbados, are concerned, now stands in a purely advisory capacity, as His Excellency has said. Whether that advice may be wanted—whether it may be sought, entirely remains with the Colonies. I am glad to say, on this my first extensive visit to Trinidad, that

I find how, happily, it is possible for one to work with the local Department of Agriculture, to find one's self at home with its Governor, its officers, and its men. I am pleased to see that such a happy state of affairs may be established, and I hope it will long continue. (Applause.) It is no function of mine as Commissioner of Agriculture to interfere with, or to dictate terms or matters in relation to, the Colonies I have mentioned. The Secretary of State for the Colonies has recently, in despatches, perfectly clearly laid down the position as regards the functions of the Department, in relation to these Colonies, and I would like to express publicly, and with all sincerity, my gratitude to His Excellency, for the excellent terms of the despatch, which has been communicated to me officially, in regard to the manner in which this Colony of Trinidad received that despatch of the Secretary of State, as to the relationship which obtains between my Department (if I may call it mine) and the Government of Trinidad—a relationship which his Excellency promised—and which I actually find to exist—would obtain between us. This has been well borne out in the present week that we have spent here, and in all my relationships with this Colony. (Applause.) With regard to the smaller colonies, one's relationship is rather more intimate, and I rejoice to say that the intimate relationship is of the pleasantest. (Cheers.) I am pleased to feel that in going from island to island officially, I am perfectly at home in every one of them; I feel that the Department of Agriculture is cordially welcomed by the Administration, and that I, both personally and in my official capacity, can feel myself at home—so much so that a leading official said to me the other day that he envied me my work because it is always associated with pleasure. Well, that may be so. I have perhaps been a little serious in thus sketching the functions of the Imperial Department of Agriculture, but it appears to me desirable, having an opportunity to respond to the kind toast which His Excellency has moved, to state publicly and clearly, what I believe to be my official functions, what I believe to be my relationships to the various Governments, and to express my appreciation of the position in which I find myself standing with regard to so many of you. I have been kindly received; my work has been helped forward in many cases in a way which is most gratifying, and which I hope will tend to public advantage and public good. (Cheers.)

You are aware that, as matters now stand, the Imperial Department of Agriculture is only in the nature of a stop-gap. It was formed to meet a special depression which existed, and was recognised as existing, by the Royal Commission in 1897; it was formed for a definite period of ten years; liberal grants were given during that period of ten years, liberal grants were given for another period of five years; from now onwards, for another period of nine years, the Imperial grants are practically for the maintenance of the central establishment only. I stand, therefore, maintained by the Imperial Goverment, and only able to carry out my duties by the willing co-operation and collaboration of the several Governments with whom I am brought into contact. How much can be done, and how much

will be accomplished, will depend not only on my efforts and the efforts of those who are working with me, but on the attitude which may be maintained by the Governments themselves. Those attitudes are extremely friendly in most cases, and I scarcely expect that when the nine years expires there will be any real termination of the work of the Department of Agriculture, but some form of evolution will take place and it will grow into greater and greater things. (Hear, hear.) What that may be, it is far from me to think; but with the tendency toward agricultural federation, I can only hope that the future of the Department of Agriculture will tend toward linking up Agriculture in the West Indies. I hope that may be its duty; I hope that may be its good fortune—that it may be the medium of bringing together the several West Indian Islands with their various interests as no other organization can do. (Applause.) We tend now to group ourselves more and more, to work more and more in harmony and to speak with a more united voice; and I hope it will be through the medium of this Department that that will be achieved, in a sense which we to-day little realize. I thank you cordially for the very kind way in which you have accepted His Excellency's good wishes for this Department; I hope that our relationships may long remain cordial; that there will be more activity; that our work may grow, and that other and more Conferences of the kind we are now holding will be the outcome of the work, having a useful and binding influence; and that we shall see the West Indies speaking with that united voice which some of us in our fondest dreams hope will be the case, at no very distant time. (Great applause.)

Mr. J. W. McConnel (England): Your Excellency, Mr. President, and Gentlemen—I have been asked to propose the next toast which is on the list before you, namely, 'The Prosperity of the Department of Agriculture, the Board of Agriculture, and the Agricultural Society of Trinidad and Tobago.' In asking me to propose this toast, your Committee has acted, I think, on truly British principles. (Hear. hear.) I understand it is the almost invariable custom of the Prime Minister when he is entrusted by His Majesty with the formation of the Government, to select for the various offices, gentlemen who have had no previous knowledge of the subject with which they have to deal. (Loud laughter.) I, Gentlemen, I am sorry to say, have almost no knowledge of the subject of agriculture; I have absolutely no knowledge of the subject of Departments, of the subject of Boards, or of the subject of Societies; therefore I feel that I am the proper person to propose this toast. (Laughter.) I have been told that if I were to read the most valuable and interesting pamphlet which was put into our hands when we came here as strangers, it would enable us to find our way and enjoy the hospitality of Trinidad, and I should also be able to speak with clearness as to the duties of these different bodies and the success they have each attained in the way they have performed their duties. I am sorry to say that in the short interval at my command, I have utterly failed to grasp any respect in which these Boards differ from one another. (Laughter.) All I can say is, that it appears to me

that the Department of Agriculture is truly official; the second one is semi-official, and does all that it thinks the first has not done and should have done; and the third is highly unofficial and criticises both the other two and supplements what they have not done. (Prolonged applause.) That may or may not be entirely true, but there is one thing that is perfectly obvious, and it is this: that the community of Trinidad has set itself to organize as well as it can, and seriously to attempt the organization of the scientific study and control of the most important subject of agriculture. That is a matter on which you in Trinidad deserve the highest congratulations. (Cheers.) I am sure this subject of agriculture is one which deserves the serious attention of the Government not only of this island, but of the British Empire as a whole (cheers); and I do trust, speaking for the distant future that Dr. Watts has alluded to, that this beginning of federation, this beginning of the organization of agriculture, may spread throughout the Empire until the British Empire organizes its Department of Agriculture, so that the knowledge obtained by one of its dependencies may be common to the whole Empire, and the different parts of the Empire may be centralized and organized together, so that in time to come the British Empire may afford as much agricultural assistance to its subjects, as the United States of America. (Cheers.) Before I pass away from these Departments I must express my very great pleasure in regard to the name of the gentleman who is to respond to this toast. I have met Professor Carmody (cheers) I think, once before; I met him on the boat in coming here but I have known him long enough now to know that he is not only a host in himself, but a perfect host to those who come about him. (Cheers.) He combines ability and perseverance in the performance of the duties of his office, with extreme kindness and hospitality to those strangers who come here. It therefore gives me the greatest possible pleasure to associate his name with this toast. Returning to the subject of agriculture, we are coming now to the time when this is studied scientifically with the advantages of science and a knowledge of the forces of nature and the effects of electricity and chemistry and of the other activities that I do not know how to speak of, and the knowledge also of those secrets of life which underlie the study of bacteria of the soil. I think we are just at the beginning of the age which may be known as the agricultural age, when mankind will get from the soil that which is to be got, in full measure. (Cheers.) If that is so in the smallest degree, I can only say that I envy, from the bottom of my heart, those gentlemen who have the knowledge to enable them to study these matters for the rest. In conclusion, I ask you to join me in drinking to the health of the three bodies engaged in the study of Agriculture in Trinidad, and also the health of Professor Carmody. (Applause.)

The toast was drunk with much enthusiasm.

Professor P. CARMODY (Trinidad), who, on rising to respond, was received with cheers, said that the Department of Agriculture in Trinidad had had its struggles, but in spite of that, it had managed to emerge from them with some degree of success.

Those who were strangers to the Colony could criticize impartially the work which had been submitted to them in connexion with the excursions which had been arranged for their information, and it was for them to say whether the organization which was barely three years old, had justified it existence so far. He was struck very much to-day by a remark which was made by the delegate representing the Royal Botanic Gardens, Kew, who is a man of wide and great experience in connexion with the agricultural work of the whole of the British Empire: he alluded to Mr. Hill. That gentleman said that he was surprised at the amount of specialized work undertaken in the West Indies mainly by the officers of the Departments, when they had so much other work to do. (Cheers.) In regard to the Department of Agriculture in this Colony, he should like to point out what had been done in some of those directions in regard to the older industries—cacao and sugar. It might be considered that these old industries had already done all the experimental work necessary for their success, but the Department found that it was absolutely necessary to begin as it were from the beginning and to start manurial experiments on a large scale. He did not wish to say anything in depreciation of the cultivators of cacao in the island: the success they had achieved was remarkable, in view of the fact that, with an area only of 1,700 square miles, the Colony ranked fourth in the world's production of cacao. That was a work of which he thought the cacao cultivator in Trinidad might well be proud. (Cheers.) But nevertheless, the scientific knowledge of the cultivation of cacao was very limited. In addition to their efforts in connexion with the older industries, the Department had done certain other things, and the latest among their achievements was the production of a hybird cotton, the success of which was owing entirely to the efforts of Mr. Thornton, who in a quiet way had been working on the subject for the last four or five years. (Cheers.) One of the most promising of the industries they had undertaken was cassava. This was an article of commerce which had recently attracted a good deal of attention, but he attached importance to it chiefly as a rotation crop in connexion with some of their staple industries. One thing that our West Indian Colonies had suffered from more than another was the absence of rotation crops, which could be grown and sold at a profit. He should like to emphasize that the work of the Departments of Agriculture in the West Indies should be directed seriously to the production of rotation crops. Another industry to which attention might be called was rubber; and those of them who had seen the exhibits at the Agricultural Show must realize that Trinidad was making great strides in that direction. The latest matter to which the Department had given attention was the production of oil, which most of the delegates had had the opportunity, the day before, of seeing, through the kindness of Mr. Cochrane. (Cheers.) That might not be an agricultural industry, but it may become of great utility in agriculture. In conclusion, he could only say that he was very grateful indeed for the kind words said by Mr. McConnel, the representative of the British Cotton Growing Association, who had come here, he supposed, with an im-

partial mind to criticize their cotton; he was glad to find that he had spoken favourably of it, and he was pleased with the very kind way in which they had received what Mr. McConnel had said. (Applause.)

Mr. McConnel: I see that this toast should have been responded to by the Mycologist to the Trinidad Board of Agriculture. Not knowing who that is, I called upon Professor Carmody, with whom I am acquainted.

Mr. J. B. Rorer (Trinidad): Your Excellency and Gentlemen: Mr. McConnel has so well given you the definition of the work of the Board of Agriculture, I need not elaborate upon it (cheers); but with Your Excellency's permission, I will thank Dr. Watts for bringing this Conference together in Trinidad and giving us younger men who are working here in tropical agriculture an opportunity of meeting each other and exchanging views on the various subjects in which we are interested. (Cheers.) In this way, for us at least, I think the Conference has been of inestimable value. (Cheers.) I know it has been to me and to other officers of the Board of Agriculture, for they have told me so. Of course we are here working primarily for the good of Trinidad, but what is good for Trinidad is good for all the other islands, and we are only too glad to give all we can, and we receive much in return. (Cheers.)

Lieut-Colonel J. H. Collens (Trinidad), replying on behalf of the Agricultural Society of Trinidad and Tobago, said the honour was one which he appreciated very highly. Mr. McConnel in proposing the toast, had referred chaffingly to the functions of the three agricultural bodies of the Colony, characterizing the Department of Agriculture as an active body, the Board of Agriculture as a passive body, and the Agricultural Society of Trinidad and Tobago as an interfering body. (Laughter.) However that may be, he (Mr. Collens) trusted that whenever the Agricultural Society did interfere or criticize it would do so properly. He did not see, himself, why the Society should be thanked by the visiting delegates; it seemed to him that the Society should thank the delegates for coming here and giving them their views and advice in regard to agricultural matters, which could not fail to be of the greatest benefit not only to them in Trinidad, but to all the West Indies. He could not help feeling that the outcome of this Conference would be a scheme of agricultural federation in the West Indies, which would bring the Colonies much more closely in touch; and it was not difficult to conceive that the West Indies would be represented in the Imperial Councils at home, just as the bigger Colonies were. (Applause.)

Professor P. Carmody (Trinidad), in proposing the toast of the visiting delegates, said it was entirely owing to the efforts of the Reception and Organizing Committee, and particularly the work done by Mr. Freeman (cheers), that the success—he might call it the phenomenal success—in dealing with so large a number of delegates had been obtained Looking at the arrangements as they had experienced them during the last few days, and which they might safely conclude would continue during the next two or three days, no

one would find the least fault with what had been done by the Committee; everything had worked out in detail as perfectly as one could wish. The number of visiting delegates was larger than at any previous Conference; they were particularly pleased to make the acquaintance of those from England, Surinam, and elsewhere, who had for the first time attended West Indian Agricultural Conferences, and he hoped it would become the practice of all the surrounding countries, Venezuela included, to send representatives to the Agricultural Conferences held in the West Indies The remaining members of the Conference he would divide into two sections: one section would include old veterans who had attended every Conference in the West Indies since they had been instituted, the other would include younger members, and members new to these Conferences. They were all equally welcome, and he hoped they would leave these shores with pleasant recollections of Trinidad, and warmest wishes that they would return to Trinidad for the next Conference. (Applause.)

The toast was drunk with enthusiasm.

Mr. J. W. McConnel (England), on his own behalf, and that of the British Cotton Growing Association which had sent him, briefly thanked the delegates for the kind way in which they had drunk his health and that of the visiting delegates.

Mr. A. W. Hill (England) said this Conference had been memorable in that he believed it was the first time that representatives from Great Britain had been present at their deliberations, and on behalf of those of them who had come on the invitation of the Imperial Commissioner to this Conference, he had the greatest pleasure in returning their warmest thanks —he believed they were six in number, including two representatives from the British Cotton Growing Association; Mr. Marshall represented the Entomological Research Committee, and he understood he was also to say something on behalf of the two representatives in the persons of Mr. Sandbach Parker, and Mr. Davson, who represented the West India Committee. The experience that he had gained in coming to this Conference had been enormous; it had given one a living interest in all the work that was being done in the West Indies. It was quite impossible to gain that from reading the numerous and interesting bulletins and papers that were issued from the various Societies and Departments, copies of which lined the shelves in his office at Kew. Their thanks were very greatly due to Dr. Watts for all the kindness he had shown them and the great trouble he had taken in providing for their being able to see as much as possible during their stay. From the first moment he came on board the boat on her arrival at Barbados Dr. Watts took them in hand and arranged for a visit to the Northern Islands, and with the greatest care and kindness saw about every detail that was thought necessary for their comfort as strangers in this part of the world. At Barbados they were also most kindly received and entertained by Sir Frederick Clarke and Mr. Bovell, and shown many features of interest in connexion with the work of the Local Department of Agriculture; and at all the other islands where they were

put ashore they were received with the greatest kindness. In Dominica he was immensely interested in all he saw, and since he had been back in Trinidad he was lost in admiration for all he had viewed around him. Their thanks were also due to the Royal Mail Steamship Company for their generosity in placing passages at the disposal of the English delegates. It had been of great value to them to have come out in this way, and he was sure they should all take back very pleasant recollections of this Conference and of the many friends they had made, and of all the kindness they had received. In conclusion, he should like to make reference, as regards his connexion with Kew, to the numerous representatives of Kew who happened to be in the room. He had been immensely struck by what he had seen of the work of the officers who are engaged in the islands in agricultural matters in the various departments, and he was sorry he was unable to go to all the islands, and to British Guiana, to see the work that was being done there—work of a kind of which they at home did not fully realize the extent. One imagined that the work of the various officers was somewhat similar to that which was being done at Kew, but that was not so. At one time they were employed on work of a commercial character; they work on experiments, and at the same time they had to maintain a Botanic Station to the approval and pleasure of everyone in the place. (Cheers.) He could say no more, but thanked them and everybody else in the West Indies who had contributed to the very pleasant and enjoyable stay which they had all made in these islands. (Applause.)

Dr. P. J. S. CRAMER (Dutch Guiana), the Hon. B. HOWELL JONES (British Guiana), Major the Hon. J. A. BURDON (Barbados), Mr. D. CAMPBELL (Jamaica), His Honour E. J. CAMERON (St. Lucia), and the Hon. E. B. JARVIS (Antigua), also replied in suitable terms on behalf of the respective Colonies which they represented.

The Hon. S. W. KNAGGS (Trinidad) then proposed 'The Prosperity of the Agricultural Societies of British Guiana and of the other West Indian Colonies'. He knew little about the Agricultural Society of British Guiana or those of the other Colonies, but he could say, with regard to the Agricultural Society of Trinidad, that it was doing a very great work in the Colony; it was probably the largest and most efficient elective body in the Colony, and with regard to agriculture generally, he thought they were trying to live up to the high model set for them by Sir Daniel Morris, and now by his successor, Dr. Watts, the head of the Imperial Department of Agriculture. (Applause.)

The toast was drunk with enthusiasm.

Professor J. B. HARRISON (British Guiana) briefly responded, remarking that he would remind his hearers that the Agricultural Society of British Guiana was the second in point of age in the British Empire, the only Agricultural Society of equal standing being the Royal Agricultural Society of Great Britain (Cheers.)

Sir FREDERICK CLARKE (Barbados), on behalf of himself and his fellow delegates representing the Agricultural Society

of Barbados, thanked Mr. Knaggs for proposing the prosperity of the Society, and the delegates for the kind way in which they had received the toast. The Agricultural Society of Barbados, if not as old as the Royal Agricultural Society of England or the Agricultural Society of British Guiana, was still, he believed, fairly old; it was associated with the name of a Governor of Trinidad and a Governor of Barbados before, he believed, he was born. He had also to thank the people of Trinidad for the very kind reception and the profound hospitality with which they had treated them. (Applause.)

The Hon. D. S. DE FREITAS (Grenada), and Mr. A. P. COWLEY (Antigua) also suitably responded on behalf of the Agricultural Societies of their respective Colonies.

Mr. C. SANDBACH PARKER (England) proposed the toast of the Organizing and Reception Committee, congratulating them on the excellent arrangements which had been made, and which had contributed so much to the pleasure and comfort of the delegates during the time they had been in Trinidad.

The toast was drunk with much enthusiasm.

The Hon. S. W. KNAGGS (Trinidad), in responding, said he happened to be the Chairman of the Reception Committee, and he need hardly say as Chairman what great pleasure it had given the Committee and the Colony generally to be able to do anything for the comfort of the delegates. He must add, however, that the success of the arrangements were due, in the first instance, to the work of two gentlemen—one His Excellency the Governor (cheers), and the other Mr. Tripp. (Applause.)

Mr. E. TRIPP (Trinidad) said he had the honour to be a member of the Reception Committee, but he thought if credit was due to anybody it was due to Mr. Freeman. (Cheers.) The Reception Committee was exceedingly obliged to the delegates who were present, and valued highly the fact that members of the Conference appreciated anything that it had been able to do. He thanked them for the reference that had been made to the Agricultural Society, which had been founded by Sir Napier Broome about seventeen or eighteen years ago, and who in his inaugural address said he hoped it would become the parliament of Agricultural matters in Trinidad. He (Mr. Tripp) did not think they had so far failed very much in that respect; they had lived up to and endeavoured to realize Sir Napier's prediction. (Applause.)

The party then separated.

On Sunday, January 28, an afternoon excursion was kindly arranged for delegates, by the Royal Mail Steam Packet Company, to the islands near the Bocas, the Floating Dock, and to other features of interest.

Previous to the morning session, of Monday January 29, a demonstration of matters relating to rubber was held at the St. Clair Experiment Station, at 7.30 p.m. The following account of this has been furnished by Mr. A. E. COLLENS, Officer in Charge of the Rubber Investigations, Department

of Agriculture Trinidad, by whom the demonstration was made:—

On arrival at St. Clair, the delegates were conducted to the tapping field, where twenty-five Hevea trees, out of the fifty under experiment, had been selected. The trees were labelled with their respective yields during the tapping seasons of 1910 and 1911. Tapping was commenced by two tappers, and the process was explained; and all questions relating to the method, and the trees were answered. Comparisons were made between the use of gouges and chisels in tapping Castilloa trees, and the results demonstrated.

After tapping was finished, the delegates gathered round the tables, on which types of knives, gouges, coagulating and smoking apparatus, reagents and specimens of Hevea, Funtumia, Castilloa, Ceara, Ficus, and Landolphia rubbers were displayed. The lecture then proceeded on the following lines.

TAPPING. Attention was drawn to the various systems employed on the Hevea trees under experiment, and the advantages of the half herring-bone system on one quarter of the girth of the tree pointed out; one tree so tapped yielded 6 lb. of rubber in six months. It was explained that the tappers attached to the Department excise, on an average, $\frac{1}{25}$-inch of bark in each tapping; in some cases this falls as low as $\frac{1}{30}$-inch.

The advantages of the use of the thin chisel knife in tapping Castilloa, and also the relative area drained by each cut, were described.

TREATMENT OF LATICES. The treatment of Hevea and Castilloa latices was shown experimentally. Although acetic acid is now generally used as a coagulant (nine-tenths of the total plantation rubber is coagulated by means of acetic acid), the use of sulphuric acid in proper proportions has probably not received the attention it deserves, as it possesses at least twenty times the coagulating power of acetic acid and is proportionately cheaper.

It was previously believed that sulphuric acid caused the rubber prepared by it to deteriorate, but excellent rubber of good quality has been prepared with the reagent applied in proper proportions.

Contrary to expectation, sulphuric acid is useless as a coagulant for Castilloa.

The method of preparing Castilloa sheet rubber, as this is in general use in Tobago, was explained.

TREATMENT OF BISCUITS, ETC. The preparation of biscuit and sheet rubber was next demonstrated; and a smoke box, in which termites' nests were used as fuel, was exhibited in working order, and the method of controlling temperature, which was maintained constant at 35° to 40° C., explained.

GENERAL. Specimens of Hevea biscuits, which had been recently valued in London as equal to the best plantation Hevea, were shown, and contrasted with lower grade rubber from known inferior trees, and the physical differences of such trees from true *Hevea brasiliensis*, in bark, seed and leaves, detailed.

After a brief but interesting discussion, in which His Honour E. J. Cameron, Professor Harrison, Dr. Cramer, Messrs. Waby, Auchinleck, Sands, Tempany, J. Jones and others took part, the delegates adjourned to the Victoria Institute for the session in which rubber was dealt with.

RUBBER.

The session in which papers and discussion relating to Rubber were taken was opened by The PRESIDENT at 9 o'clock a.m. on the same day (Monday, January 28). In introducing the subject, The PRESIDENT referred to the demonstration of rubber-tapping and related matters that had just been held at the St. Clair Experiment Station, and congratulated the Department of Agriculture and everyone concerned in the demonstration, including Mr. A. E. Collens, on the clear and interesting manner in which the work was conducted.

The first paper to be taken was entitled Rubber Experiments in Trinidad and Tobago, by Mr. A. E. COLLENS, F.C.S., Officer in Charge of Special Investigations, Department of Agriculture, Trinidad. Its chief features were as follows:—

A history is given, first of all, of the introduction of rubber plants into Trinidad. This is followed by an account of the experimental work for the past year, commencing with a description of the characteristics of the different kinds of trees. Details succeed, of the results of tapping, and of market reports of samples of rubber sent to England for examination. In regard to tapping, a matter of some interest is that the system consisting of a single herring-bone, on a quarter of the girth of the tree, has been found best for Hevea. Such of the work that is described, up to this stage, was conducted at the St. Clair Experiment Station, and in the Emperor Valley. Other work was also done at Non Pareil Estate, Sangre Grande, on behalf of the proprietor. The trees were four and a half years old, and were tapped for sixteen days, the work being done on alternate days, on the Gallagher system—a single V at 1 foot from the ground. The yield of rubber during the time of experiment was 3½ lb.; this did not include the scrap, which was lost. It is advised that the trees should not be tapped until they are about 2 feet in girth, and that the single herring-bone system should be employed up to about 5 feet. The biscuits were prepared by coagulating with sulphuric acid at a strength of 5-per cent.; they were reported upon at the International Rubber Exhibition, 1911, as follows: 'Fine, well prepared smoked Hevea biscuits in excellent condition . . . . . these biscuits show little room for improvement.' Analysis of them showed that they possessed the following percentage composition: water 0·50, albuminoids 2·75, resins 5·05, caoutchouc 91·44, insoluble matter 0·26.

Particulars are given of investigations of various methods of preparing rubber in sheet and biscuit form; it was found that sheets prepared by quick coagulation, and blocked, are much tougher than ordinary biscuits, and that sulphuric acid of the strength mentioned above is the best coagulant. This part of the

paper concludes with particulars of market reports and tapping experiments relating to Hevea.

Details of tapping experiments with *Castilloa elastica*, at Verdant Vale, and at Lure estate, Tobago, are then given, as well as market reports on samples of rubber from these sources. Mention is also made of inconclusive experiments that were carried out for the purpose of ascertaining if the percentage of rubber in latex can be determined roughly by means of a hydrometer.

In reply to Mr. H. A. TEMPANY (Antigua), Mr. Collens stated that the circumstance whether Hevea will thrive better in heavy or in light soils is entirely a matter of rainfall, and in further answer to Mr. T. THORNTON (Tobago), informed him that comparative records of the cost of tapping Hevea and Castilloa had not been kept in Trinidad. Mr. THORNTON said that the cost of tapping Castilloa in Tobago is about 1s. per lb. Mr. W. N. SANDS was further informed by Mr. Collens that the highest elevation at which Castilloa is growing, in Trinidad, is about 600 to 700 feet.

In an address which followed, dealing with Notes on Rubber Plantations and Experiments in British Guiana, Professor J. B. HARRISON, Director of Science and Agriculture, British Guiana, after making reference to the attempts, more than thirty years ago, of the late Government Botanist in British Gniana, Mr. Jenman, to arouse the interest of planters in Para rubber, stated that this had been planted rather extensively in the Colony, during the last four or five years. As, however, the Botanic Gardens are not in a situation suitable for the growing of Hevea, seed has had to be obtained, as it was required, from the Straits Settlements, and occasionally from Ceylon, and since 1906, 250,000 plants have been raised and planted out in various parts of the Colony. This is in addition to a large quantity of seed that has been obtained by private individuals, and used for raising plants. These are found to grow best, as far as is known, in districts about 8 or 10 miles from the coast. In illustration of his remarks, Professor Harrison drew attention to a pamphlet dealing with rubber and balata in British Guiana, copies of which had been distributed among the members of the Conference. As regards the quality of the rubber obtained so far, this was shown to be good by the fact that the silver cup, awarded at the recent Interntional Rubber Exhibition, for the best rubber from the West Indies, had been won by British Guiana. Professor Harrison proceeded to give particulars to show the size of the plantations of rubber that are being made in the Colony, in some cases in Crown lands granted by the Government on lease. The Government's share in the work was concerned mainly with the importation of seed, the raising and selling of young plants, and the conduct of experiment stations at several places, the object of the latter being to test various conditions as to their suitability in relation to growing Hevea. The investigations had proceeded far enough to show that: 'there is land in Demerara pre-eminently suitable for the cultivation of rubber.' Attention had also been given to the rubber yielded by the native Sapiums, the best of these being *Sapium Jenmani*. It was too early to say anything about the output to be expected from trees of about five or six years of age that had been planted, but experiments with

older trees had given results * that are disappointing, in many respects; some of these were detailed shortly by Professor Harrison. The problem of the behaviour, on being tapped, of old trees of Sapium, was being investigated, and it was hoped that the same conditions would not be experienced with cultivated plants of this genus.

The PRESIDENT emphasized the importance of the pioneering work described by Professor Harrison, and the value of the experiments in preparing the way for the successful commercial development af a rubber industry, drawing attention to the fact that it is far better that experiments should be carried out gradually, and in the manner contemplated in British Guiana, than that premature attempts at commercial development should be made, with subsequent possible failure and the accompanying damage to the name of the Colony.

After discussion had been invited by the President, Mr. G. G. AUCHINLECK (Grenada) desired to be informed on questions having to do with the following matters: (1) if Hevea seeds (as had been found in Grenada) had been noticed by others to have deteriorated seriously when they had been received from the East, packed in dry charcoal; (2) if sulphuric acid is better than acetic acid for coagulation, having regard to the eventual development of tackiness; (3) if the tapping of Sapodilla trees for gum is likely to become valuable.

In reply to the first question, Professor HARRISON stated that it had been found, in British Guiana, that Hevea seeds arrive in best condition when they are packed in slightly damp charcoal—that is charcoal containing about 10 per cent. of moisture, in packages that are closed, but not hermetically sealed, and quoted actual experience in connexion with this fact. Mr. T. THORNTON (Tobago) suggested the making of experiments with seed of one origin, all produced under the same conditions, but packed in the different ways that had been mentioned; Professor HARRISON was satisfied, however, that the method using charcoal containing 10 per cent. of moisture and packages that are not hermetically sealed is efficient, particularly as it had yielded excellent results, and his opinion as to the relative merits of the methods of packing was supported by Mr. E. R. DAVSON (British Guiana). Further, in regard to Mr. Thornton's suggestion, Mr. A. W. HILL (Kew Gardens) stated that, in the earlier days, when Para rubber seeds were being sent out to the East, all kinds of experiments were tried at Kew—trials that have received report in the *Kew Bulletin*—and it was found that the method favoured by Professor Harrison was best in operation. He would like to draw attention to the disadvantage that arises from the necessity for making importations of the seeds from places where it was not possible for the importer to know anything about the trees that are producing them. The likelihood that seed is taken from trees that bear quickly, before their capacity to produce latex can be tested, made it possible that plants raised from the seeds

* Information concerning the work is reproduced in the *Agricultural News*, Vol. X, p. 379. [Ed., *W.I.B.*]

would not be very valuable. In relation to the possibility of the importation of seeds of Hevea from sources less remote than the Far East, Mr. W. G. FREEMAN (Trinidad) adduced evidence which seems to make it possible that good seed may be obtained from Brazil; such seed had actually been received, through Mr. J. R. Bovell, and tests of its germinating power were being made, in Trinidad.

In regard to this part of the discussion, The PRESIDENT drew attention to the importance of the point mentioned by Mr. Hill—the origin of the seed as regards the trees producing it, and in relation to the same subject mentioned the usefulness of the work, that had been begun in Trinidad, of studying the individual characters of the trees. The suggestion was made by Mr. J. R. BOVELL (Barbados), with respect to the obtaining of good rubber seed, that a person possessing a knowledge of the kind of rubber trees required should be sent to Brazil, in order that he may select and ship the seed required, the expense of the work being divided among the colonies interested in Para rubber. It was advocated by Mr. E. A. ROBINSON (Barbados) that rubber trees should be planted closely, and that those found to be inferior as rubber producers should be removed subsequently, in the thinning out. Dr. P. J. S. CRAMER (Surinam) mentioned that examples existed, however, in the Federated Malay States, of widely planted cultivations which contain better trees than those in plantations where the plants had been put in closely and then thinned out to the distances of the wider planting. In regard to Mr. Hill's remarks on variation in quality among rubber trees, Mr. T. THORNTON adduced an example in which, on an old estate in Tobago, there are a number of Castilloa trees that have never produced any rubber. After a question by Mr. A LEECHMAN (British Guiana), asking if it is assumed that quick-bearing trees produce no latex, Mr. A. W. HILL stated that he had not wished to infer that a quick-bearing tree is necessarily inferior, from the point of view of rubber production, but that it was dangerous to obtain seed from such trees, because there had not been time or opportunity for their latex-producing property to be tested. Mr. A. LEECHMAN asked, further, if the fact of bearing seed affects the power of the tree to produce latex, and was informed by Dr. P. J. S. CRAMER that, in his opinion, seed may be taken from any trees producing it, as long as it is certain that they are good yielders of latex. As a summary of a matter under discussion, Mr. J. F. WABY stated that the question did not appear to relate so much to the age of the tree, or to the taking of seed from a quick-growing tree or any other kind of tree, as to the using of untested trees as a source of seed; and with this view of the subject the PRESIDENT agreed.

In reply to one of Mr. AUCHINLECK'S questions, asking if sulphuric acid is better than acetic acid, for coagulation, in relation to tackiness, Mr. A. E. COLLENS replied that acetic acid is found to be too expensive for the purpose, and that lime juice is almost the sole agent employed in Trinidad; while with reference to sulphuric acid, this could not be used for coagulating Castilloa latex, as its effect was simply to produce a more or less homogeneous mixture. One of the

preventives of tackiness was smoking. Mr. Auchinleck's question relating to the possible future value of the sapodilla tree as a source of gum received attention from Mr. H. C. PEARSON (New York), who emphasized the importance of the product from this tree in connexion with making chewing gum, stating that it is obtained chiefly from the forests in Campeachy and Mexico, and that it is rapidly disappearing on account of the destructive way in which the gum is gathered by the natives. He therefore recommended that those who are raising the sapodilla tree should cultivate it with a view to tapping it for the supply of gum.

This part of the disucssion was succeeded by an address, by Mr. H. C. PEARSON, Editor of the *India Rubber World*, dealing with the Future of West Indian Rubber. In this, the speaker commenced by pointing out that, logically, rubber-planting should have begun and extended on the borders of the Amazon, but the opportunity was not embraced by Brazil, and had passed on to such places as British and Dutch Guiana, Trinidad, Dominica and British Honduras, and similar regions in Central and South America. In these, however, little had been done, and it had remained for the Middle East to take up the matter, and here remarkable success had been attained. In regard to the West Indian planter of rubber, the question of future competition did not arise with respect to Ceylon and the Federated Malay States, but was concerned with the production of wild Para rubber on the Amazon. Consideration of the general question of the demand for rubber led to the conclusion that the present requirements by manufacturers would become double of the present quantity in the near future, and the opinion was given that the supply for this will be made eventually from plantations, for the greater part. In the opinion of the speaker, competition is little to be feared, in the West Indies, from Brazil, while it is very unlikely to arise from the Middle East; so that with the advantages of soil and climate possessed by this part of the world, and the ease with which good agricultural advice may be obtained, there is no reason why rubber-planting in the West Indies should not be greatly extended.

The PRESIDENT, remarking on what Mr. Pearson had said, stated that this was likely to be very reassuring to those who contemplate the extensive development of rubber-planting in the West Indies. The outlook for the future was most encouraging, and it appeared that extensive planting of rubber may take place, provided that care is taken to obtain and employ good kinds of seed and plants. He then invited those who may wish to address questions to Mr. Pearson to make use of the opportunity.

In replying to a question by Mr. S. SIMPSON (England), regarding possible future competition between natural and synthetic rubber, Mr. PEARSON referred to the fact that, as turpentine is used in the manufacture of synthetic rubber, any large production of this would have the effect of raising the price of turpentine to such an extent that the artificial rubber would eventually be a good deal higher in price

than three-dollar rubber. He thought that the time would come when synthetic rubber would be used very largely by manufacturers, but that this is at present very remote. With reference to the subject, The PRESIDENT mentioned, as a matter of interest, that he had assisted Sir William Tilden, who was the first to make synthesized rubber from isoprene, by preparing for him the material from which that rubber was made; he further knew that Sir William Tilden's views in regard to synthetic rubber were very similar to those of Mr. Pearson. Professor P. CARMODY (Trinidad) also made a few remarks concerning synthetic rubber, referring to the time that it had taken investigators at the recent International Rubber Exhibition in London, to make the product, in answer to a challenge; and expressed his opinion that there is not the least danger of competition—certainly in the lifetime of the present rubber planter. Lastly, in answering a question by Mr. J. R. BOVELL, Mr. H. C. PEARSON stated in regard to the trees yielding Sapodilla, or similar gum, which he had spoken of, that the identity of these was not determined.

An abstract of a paper was then presented entitled, Notes on Castilloa Rubber in Dominica, by JOSEPH JONES, Curator, and G. A. JONES, Assistant Curator, Dominica Botanic Station, as follows:—

Castilloa was introduced into Dominica in 1891, and the four original trees are growing well, in the Botanic Gardens. They have yielded material for growing all the trees of the species that are at present in cultivation in Montserrat, Antigua, St. Kitts and the Virgin Islands, as well as for raising other specimens in Dominica. The estate cultivation of Castilloa in that island is small.

Work by the United States National Herbarium has increased the number of species of Castilloa from three or four to ten or eleven. Possibly as many as four species are at present under experimental cultivation in these islands. The first steps for the identification of the species were taken by the Jamaica Agricultural Department, and it is now known that *Castilloa guatemalensis* and *C. costaricana* are growing in that island. Similar action has been taken in Dominica, at the instance of the Imperial Commissioner of Agriculture, and Dr. O. F. Cook tentatively regards the species in that island as being the true *C. elastica*, Cerv., of Eastern Mexico; though the final determination is awaiting Professor Pittier's return from Panama. In the meantime, the opinion was given by a rubber planter, travelling through the West Indies a few months ago, that the species of Castilloa in the Dominica Botanic Gardens is not the same as the one cultivated in Trinidad. The species grown in Dominica is best suited to the lowlands with a high temperature and a moderate rainfall.

The method of tapping Castilloa in Dominica is similar to that commonly employed in Trinidad and Tobago; it is described in the paper. A description of the preparation of the rubber is also given, and it is pointed out that not more than twenty-four hours is required for the process, the completion of which should be attained as quickly as possible. The product is white, at first,

with proper preparation, and the colour becomes brownish, on drying. The results are given of an analysis made at the Antigua Government Laboratory, of a sample of rubber prepared in the way described, and the report on this is quoted as saying that the colour of the sample was very good, as also were its elasticity and tenacity. The resin content was somewhat high, and a trial was made for reducing this by washing the latex with a dilute solution of caustic soda, when little diminution was obtained.

Tapping experiments with trees of different ages at the Gardens resulted as follows: trees twenty years old gave a cal culated yield of 1 lb. 8 oz. per annum; those thirteen years old, nearly 3 oz; and those twelve years old, just over 3¼ oz; there were four trees of the first kind, nine of the second, and thirty-seven of the third. Similar experiments on estates have given very small yields. The figures show that the promise of satisfactory yields is only given by the older trees; as this is only 1½ lb., and twenty-five of the trees would occupy an acre of land, the total yield per acre would be only 37½ lb. of rubber, which, valued at 3s. per lb., would give a return of less than £6 per acre—and this only after the trees have been growing for twenty years, and with the plants at their best development.

Reference is made to the replacement of the first high yield, in Castilloa, by later low ones, and a consideration of a remedy proposed for this, in which the lowness of the yield is made up for by an increase in the number of trees, points to an experiment in which close planting was employed with the result that success was not obtained, for at the end of eight years only badly grown trees were obtained which yielded a very small quantity of latex. A comparison is made of such matters in relation to the returns obtainable from Hevea.

The growing of rubber plants in the light of labour conditions in the West Indies is considered, and it is shown that the matter wears a much more serious aspect in regard to Castilloa than with reference to *Hevea brasiliensis*.

The article concludes by pointing out that, at the present time, the latter class of rubber: 'still remains, after years of experiments with other rubber trees, the only tree that has given general satisfaction under cultivation.'

In the discussion which followed, Mr. D. CAMPBELL (Jamaica) stated that he thought that the first introduction of Castilloa into Jamaica was from Kew; since the time of this, other varieties had been brought into the island, including the Costa Rica Castilloa (*Castilloa costaricana*), which he had seen flourishing in that country and had consequently placed great faith in it. It was stated by Mr. W. E. BROADWAY (Tobago) that the Castilloa in Tobago had been identified at Kew as *Castilloa elastica*. Further, Mr. S. SIMPSON gave the opinion that there is little doubt that areas of Castilloa trees exist, in many parts of the world, where the plants are not *C. elastica*, and in answer to The PRESIDENT stated that the varieties of the plant of which he had had experience had proved to be worthless. In pursuance of the subject, Mr. H. C. PEARSON termed Castilloa, in view of his experience, as: 'the most provoking arborescent weed that ever flourished on earth,'

saying, however, that under conditions that are suited to it, the plant will form a magnificent tree and give good latex from which good rubber can be obtained. It was further the opinion of this speaker that planters in Tobago had more nearly solved the problems of tapping the trees and dealing with the latex than any other growers of Castilloa in the world, and he believed that work would soon be accomplished by botanists which would render certain the identity of the best kinds. Continuing the subject of the identity of the different kinds of Castilloa, Mr. W. G. Freeman drew attention to the fact that, originally, *Castilloa elastica* was thought to include only one or perhaps two, species, whereas the genus Castilloa had now been divided into several species, and the present problems were the identification of these and the determination of their yields.

Mr. Norman Lamont (Trinidad) made reference to the question of the distance to plant Castilloa, that had been brought up in the paper entitled Notes on Castilloa in Dominica, asking for a definite statement as to whether wide or close planting is best suited to the tree. He thought that, in Christy's work on Funtumia, a distance of 5 × 5 feet or 6 × 6 feet was recommended for plants of that genus, while the experiments with Castilloa had appeared to show the superiority of wide planting. In reply, Mr. H. C. Pearson stated that, in Mexico, wide planting had been found best for Castilloa. Referring to Funtumia, and Christy's work on this genus, Mr. W. G. Freeman stated that he had assisted that author in the writing of his book, but was not certain that the planting distances quoted by Mr. Lamont were correct. Funtumia was grown closely because it formed a plant with a straight stem, instead of a bush, under this condition. Mr. N. Lamont assured Mr. Freeman as to the correctness of the distances quoted by him, and was followed by Mr. S. Simpson, who asked if anything had been done in the West Indies in regard to the experimental cultivation of Funtumia. In reply, Mr. A. E. Collens stated that there were 20,000 to 25,000 Funtumia trees in Trinidad which have grown well so far; but the yield of latex was low, and quickly decreased during successive tappings, while the rubber obtained from it was poor and deteriorated quickly. This part of the discussion was concluded by a statement from Professor P. Carmody, indicating that the planting of Funtumia on a considerable scale had been discouraged by the Trinidad Department of Agriculture.

The next paper presented dealt with Notes on the Cultivation of Para Rubber, by Mr. F. Evans, Assistant Superintendent and Curator, Royal Botanic Gardens, Trinidad. This brought forward the following matters :—

In the Malay States, the cost of bringing an acre of Para Rubber into bearing is approximately £25 to £30; the upkeep after the first five years is very small, and according to some of the most experienced Eastern planters, rubber should cost about 1s. to 1s. 6*d*. per lb. to place on the market. This should be compared with the similar cost in the West Indies.

Close and wide planting. In the East, planting distances vary greatly: 8 × 8 feet, 10 × 10, 12 × 12, 15 × 15 and 24 × 24

feet have all been given a trial. The general tendency is now to wide planting, and 24 × 24 feet, or the avenue system 30 × 10 feet, is gaining in favour. Against wide planting is the extra cost of collecting latex, and in support of it is the important fact that close planting retards the growth of the trees and also prevents bark renewal; this argument also applies with equal force to the interplanting of such permanent crops as cacao and cocoa-nuts.

AGE TO TAP. Speaking generally, trees are tapped, irrespective of age, when 18 inches in girth 3 feet from the ground; but in Malacca I saw trees 14½, 15, 16 and 17 inches in girth being tapped, and the tapping, if expertly done, does not apparently damage the tree or interfere with the growth The rubber, however, is somewhat inferior in quality.

TOOLS. The simplest tools are preferable; those in general use are the farrier's knife and the bent gouge chisel.

TAPPING SYSTEM. The first year's tapping is usually a basal V, and for subsequent years, of the many methods in vogue, the ¼-or ½-surface appears to be the best. While the ½-surface gives the greater immediate return, experience goes to prove that the ¼-surface is best for the tree and allows for a more perfect bark renewal.

There is no advantage in high tapping; it demands an undue expenditure of labour, and the latex is not as good as that obtained from the base of the tree. The cuts should be made no higher than a man can reach and not less than twenty to the inch.

On some Eastern plantations the rubber in the shavings of the daily cuts is extracted and turned into crêpe, and this pays the cost of tapping.

COST OF TAPPING. Throughout the East good workmen tap 250 to 300 trees per task, boy and women tappers doing 150 to 200 trees per task, the price paid per task ranging according to locality from 25c. to 40c. (Malay money). It will be well to compare this with the cost in the West Indies.

In opening cuts a man should deal with forty to fifty trees per task.

YIELDS. The yields vary according to local conditions, but speaking generally 2lb. for five-year old trees with a ½-lb annual increase to the tenth year appears to be a reasonable expectation.

TOPPING. Topping or thumb-nail pruning, at one time recommended with a view of increasing the circumference of the trees, is not now in general practice, experience having shown that the side or lateral branches thrown out are brittle and easily broken by winds, causing ragged wounds (open doors to disease). The low, spreading branches formed in consequence of such pruning also interfere with tapping operations.

WEEDING. In the East, clean weeding is the general practice, and costs 30 to 50c. (Malay money) per acre. The high cost of labour almost prohibits this form of cultivation in the West Indies, and it is an open question whether it is

necessary. Measurements recently taken of trees growing in an unweeded, but well-drained Trinidad plantation compare very favourably with those from trees growing in the Federated Malay States, under the conditions on Eastern plantations.

The last paper to be considered was Rubber in the Drier West Indian Islands, with special reference to Antigua, by Mr. H. A. TEMPANY, Superintendent of Agriculture for the Leeward Islands. This may be found, in full, in the *West Indian Bulletin*, Vol. XII, p. 13.

The PRESIDENT, in closing the session, referred to the usefulness of the discussions that had taken place, stating that there had been an exchange of scientific views in which information was afforded that could not be gained alone from the perusal of publications; the interchange had been most valuable, and possessed immediate application. Further, it was Dr. Watts's opinion that the rubber industry of the West Indies and British Guiana tended to benefit very largely, in the near future, from the work which had been done during the session that had just come to an end.

For the afternoon of the same day (Monday, January 29), the delegates to the Conference were kindly invited, by the Trinidad and Tobago Agricultural Society, to attend the Private View and Opening Ceremony of the Agricultural and Industrial Exhibition, held in the Prince's Building and the grounds of that institution. The invitation was accepted by most of the members of the Conference, who readily availed themselves of the opportunity of placing themselves in possession of a large amount of useful information, presented by what proved to be a most successful exhibition.

In the evening, Mr. A. LEECHMAN, F.C.S., Science Lecturer, British Guiana, gave an address, Dr. F Watts, C.M.G., being in the Chair, at the Queen's Royal College, in which he exhibited a number of lantern slides illustrative of rubber-growing in British Guiana. The information afforded was indicative of the work in progress in the Colony, at the instance of the Department of Science and Agriculture. In the lecture, particular attention was drawn to the different species of Hevea that exist, as well as to the opportunities that British Guiana offers for rubber cultivation. On the conclusion of Mr. Leechman's lecture, Dr. P. J. S. CRAMER again exhibited a selection of the lantern slides that had been shown by him already during his lecture on Rubber Cultivation, of Friday evening, January 26. These proceedings were succeeded by a general discussion, in which Professor HARRISON, Mr. H. C. PEARSON, the lecturers, and others, took part, and at the conclusion a hearty vote of thanks was accorded to Mr. Leechman and Dr. Cramer.

The delegates met at the Victoria Institute at 9 a.m. on Tuesday, January 30, for the closing session of the Conference.

The PRESIDENT, in opening the session, read a despatch from His Excellency the Governor, intimating the transmission, by telegraph, to the Right Honourable the Secretary of State for the Colonies, immediately after its receipt, the Resolution unanimously adopted by the Conference in reference to the Brussels Convention.

The PRESIDENT said, further, that the first business that morning was to consider the Resolution with regard to the appointment of a Trade Commissioner in Canada. He had already communicated to the Committee, that was asked to deal with the question, the substance of the telegram which was received by His Excellency the Governor with regard to the recommendations which had previously been made. That, he thought, had been taken into consideration by the Committee, and the discussion which took place on board the S.S. 'Balantia' had no reference to the British Trade Commissioner. Mr Howell Jones was in charge of the Resolution, and he would now receive it.

THE APPOINTMENT OF A TRADE COMMISSIONER FOR THE WEST INDIES IN CANADA.

The Hon. B. HOWELL JONES (British Guiana) then moved the adoption of the following Resolution :—

'That the appointment of a Trade Commissioner in Canada is likely to be advantageous in the event of successful negotations as to reciprocity with the Dominion, and that the advisablity of such an appointment be accordingly referred to the West Indian delegates at the forthcoming Reciprocity Conference at Ottawa.'

The Resolution, he said, had been accepted by the Committee, with the exception of Mr. Collymore who dissented. There was no necessity for him to make any remarks on the subject, because the delegates who had been appointed to consider the matter would take steps in regard to it when they went to Ottawa to deal with the question of reciprocity. He however thought it absolutely useless for them to have a Trade Commissioner in Canada until they knew that reciprocity would be established between the West Indies and Canada. The matter would then have to go before the different Legislatures to be dealt with.

Mr. NORMAN LAMONT (Trinidad) seconded the motion, and the Resolution was adopted unanimously.

IMPROVED TELEGRAPHIC SERVICE BETWEEN CANADA AND THE WEST INDIES.

Mr. E. R. DAVSON (England) then submitted the following Resolution :—

Be it resolved :—

(1.) 'That in view of the Report of the Royal Commission on Canadian West Indian Trade Relations issued in 1910 after an exhaustive investigation, His Majesty's Government be urged to give effect to that recommendation for the betterment of West Indian telegraphic conditions therein contained.

(2.) 'That a copy of this Resolution be forwarded to the Secretary of State for the Colonies and that a copy be sent to the Prime Minister of Canada, urging the co-operation of his Government in securing an improved telegraphed service between the Dominion and the West Indies.

Ones first idea, said Mr. Davson, might be that a question of cable communication was not an agricultural one ;but he thought that if those present who were planters and estate owners would consider the matter for a moment in relation to the amount of money which they spent in cables regarding the selling and shipping of their crop, they would find that it came to no inappreciable amount, and that if they—as he sometimes had done—worked out the cost and compared it with what the cost would be if they were carrying on their business in another part of the world, such as South Africa, they would find that there was a large difference in the amount they paid, and this was undoubtedly a great handicap on their industries. He thought that it would be a great pity if this Conference was to separate without giving some expression of approval of that idea, especially as its members were more interested in the subject than other parts of the Empire, and this would be the first occasion on which the West Indies would be speaking on the matter with a united voice. The recent Royal Commission which investigated trade relations between Canada and the West Indies went very fully into the question of improved telegraphic communication ; evidence was taken in the West Indies and in London from representatives of different cable companies interested in the West Indies, and also from outside telegraphic experts, and in their report they set out at length the various suggestions and proposals which they recommended to the Government for adoption. He did not intend this morning to go into those proposals ; they were necessarily indications of what should be done, and he thought it would be a great pity to discuss them in detail ; they were in the hands of the Government, and he thought they ought to leave them there. He only wished them, by this Resolution, to confirm in general terms the recommendation of the Commission, and urge the Government to continued action. He thought that was all he need say. He did not wish to touch on the broad principle of the question of advantages which would accrue to the Colonies generally—the advantages of education, or in getting longer and cheaper and better press information ; or the Imperial advantage in linking them up more closely to the Great Empire by an All-British cable. He merely contented himself with moving this Resolution, believing it to be for the benefit of the West Indies.

Mr. W. Gordon-Gordon (Trinidad) had much pleasure in seconding the resolution which had been brought forward by Mr. Davson. The question had been worn threadbare for so many years past that it made them hope that the problem was nearer solution than appeared to be the case. They all knew how long Governments took to consider these important questions, and in the present instance there was only one thing in the way that seemed to have created doubt in their minds, and that was—What part was wireless telegraphy going to play in regard to cable communication in the future? But whatever may be adopted, he thought they would all agree that there was great necessity for a

much cheaper and better system of cable communication than had fallen to the lot of the West Indies for so many years past. It was, he conceived, in the essence of agriculture, because these were agricultural colonies, and without agriculture there would be nothing for business men to do; therefore cable communication, he thought, was closely allied to the agricultural industries of these colonies

The PRESIDENT said that he would like to point out that the terms of the Resolution had regard to telegraphic communication and did not necessarily point to cable communication, alone. Therefore any sort of telegraphic communication would be included in the compass of the Resolution.

The Resolution was then adopted unanimously.

PROCEDURE AT FUTURE CONFERENCES.

The PRESIDENT called upon the Hon. B. HOWELL JONES to move the resolution concerning procedure at future conferences, of which he had given notice. This was submitted to the Conference in its original form, which was as follows:—

'That the West Indian Agricultural Conference having assumed larger proportions than when first inaugurated, and as the time at our command is so short that papers when read cannot fully be discussed.

'*Be it resolved*—That this Conference recommends the Imperial Commissioner of Agriculture that in future conferences the work to be done should be divided into sections; and that the President of the Conference should select a Chairman to preside over each section.'

After Mr. Jones had adduced his reasons for bringing forward the resolution, and after it had been seconded by Mr. J. J. NUNAN, and Mr. J. R. BOVELL and Professor J. B. HARRISON had spoken in support of it, Professor P. CARMODY stated that he was not in favour of the proposal that the Conference should be divided into sections, but considered rather that the technical officers of the various agricultural departments and similar institutions should meet more frequently. In following such a scheme, the papers of a more highly scientific nature might be printed before the holding of the general conference, and taken as read, while the practical results would be communicated to the members of this conference. In the meantime, the matter should be left for the consideration of the President.

As a preliminary to bringing the resolution before the Conference, The PRESIDENT reminded the members that the question forming the subject of the resolution had received previous discussion on more than one occasion, and expressed his thanks to them for giving attention to the matter, as the growth of the work of the agricultural conferences, and the increase in the number of delegates, fully necessitated some reorganization in the method of procedure. The matter required very careful consideration, and he would proceed to put the resolution to the meeting. While this was being done, however, Professor Carmody asked if the resolution might be

amended, and after he had conferred with the Hon. B. Howell Jones, Professor Harrison and Mr. Norman Lamont, the resolu- was amended to read as follows:—

'That the West Indian Agricultural Conference having a - sumed larger proportions than when first inaugurated, an as the time at our command is so short that papers when read cannot be fully discussed.

'*Be it resolved*—That this Conference recommends the Imperial Commissioner that some method of dealing with the increasing work of future conferences should be considered before our next Conference.'

The Resolution, as amended, was then put and adopted unanimously.

THE WORK AND OBJECTS OF THE ENTOMOLOGICAL RESEARCH COMMITTEE.

Mr. G. A. K. Marshall (England) addressed the meeting in regard to this matter, stating first of all that when he had been selected by the Entomological Research Committee to come to the West Indies, on the invitation given by the the Imperial Commissioner of Agriculture, he did not at the time realise how important a visit it would be. The first thing that he understood, in coming out to the West Indies was that there seemed to be considerable misunderstanding as to the work of that Committee, and as to the proposal made some time previously in a circular Despatch issued by the Colonial Office, suggesting that the West Indian Islands should co-operate with the Committee in furthering an interest in insect pests. That misunderstanding was due to the ambiguous terms of the despatch, owing to the fact that the conditions in the islands were very different, and it was difficult to state specific proposals which would cover the Colonies outside the Crown Colonies. He therefore took this opportunity to explain briefly the origin of the Entomological Research Committee and some of its objects.

The immense importance of entomology, both in regard to the health of human beings generally, and as regards industry of all kinds, especially of an agricultural nature, had only recently been recognised to any great extent in England; and this was largely due to the discoveries of Sir Patrick Manson and Sir Ronald Ross, with regard to the carrying of malaria by mosquitoes. The importance of this subject was now year by year more increasingly recognised, and the necessity for investigations of the kind was particularly apparent in regard to tropical West Africa, where it was shown that the backwardness in the development of the industries was chiefly due to causes arising from the presence of certain insects. This fact was recognised by Lord Crewe, who was then Secretary of State for the Colonies, and he consulted with Dr. Shipley of Cambridge with regard to stimulating men to the study of insects in order that the resources of our tropical countries might be better developed. As a result of that, the Entomological Research Committee, which is composed of scientific men skilled in the study of tropical diseases and various insects,

was formed, its duties being then confined solely to tropical Africa. It started work in Africa, sending out travelling entomologists—one to the East African Colonies and another to the West African Colonies—and the result, so far, had been most gratifying. The Committee had been in existence for two and a half years. After eighteen months' work, requests began to be received from Colonies outside, asking whether they could not be helped to control the disease-carrying insects, these requests coming not only from private individuals, but from officials in those Colonies. A difficulty at once arose, because the funds provided for the work of the Committee had been supplied entirely in the first place by certain African Colonies, and were obviously earmarked for expenditure in Africa only, and Lord Cromer was of opinion, and the Committee supported him, that it was not fair that they should utilise that money for doing work for Colonies that were not contributing. Under these circumstances, it was suggested by the Secretary of State for the Colonies that the circular despatch, to which he had referred, should be sent out, asking the various Colonies which were not self-governing, whether they would co-operate with the Committee or not, and whether the Committee would be of use to them. It was evident that in many cases that despatch was not understood, and in others, it seemed to be assumed that the object of the Committee was to collect insects. The Committee had no intention of collecting insects; insects were of no value to it, except from the importance they bore to the colony which sent them. If a Colony wished the Committee to assist it, it must send specimens of its insects, because the Committee could not get on without them. But, apart from that, these insects were kept in the museum for the use of classes dealing with instruction generally—for purposes of education.

With regard to the assistance which the Committee could give to Colonies in respect of entomological work, he must say at once that they could not do any practical work in connexion with entomology. The function of the Committee was not to assist the individual planters of a colony, but to aid the entomologist who was working for the planter. The entomologist who was appointed to a post in a tropical country, and had come out from England having no knowledge of the insects of the country to which he went, was placed at a disadvantage: he was far removed from museums, libraries, and similar institutions, and it was extremely difficult for him to understand, and know the names of, the insects with which he had to deal. The purely scientific work of naming insects was not, in the opinion of the Committee, the function of a Colonial Government entomologist; his business was to attend to remedial measures, studying the habits of the insects and giving practical assistance to planters. Therefore, there should be some central body to which a man so situated could refer, with the object of getting purely scientific work done for him. From the periodicals that were being issued, it would appear that the work of practical and scientific entomology was now enormous and increasing every year, and it was impossible for a man like that to study and keep himself abreast of what was being done. And the same was applicable to entomologists in

other colonies. Hence it seemed to him that a Committee of this kind would be of great value to the practical worker in the field; it took work off his hands, and that work was done in England where they had some of the best museums in the world. That was the assistance which was to be given to the entomologist, and not directly to the planter.

In order to arrive at some idea as to the requirements of the entomologists of the West Indies, it was suggested by the President of this Conference that he should have an informal discussion with them as to their views on the subject, and, as a result of that discussion, they had drawn up a short report which they had asked him to present in their name, and which he would now read :—

REPORT OF THE COMMITTEE ON ENTOMOLOGICAL RESEARCH IN THE WEST INDIES.

Representatives of the Conference from the Imperial Department of Agriculture, from Barbados, British Guiana and Trinidad, who are concerned in entomological investigations, acting as a Committee, have held meetings to discuss the proposals contained in a despatch from the Colonial Office (March 22, 1911) asking whether the West Indian Colonies considered it desirable to co-operate with the Entomological Research Committee.

Advantage has been taken of the presence of Mr. Guy A. K. Marshall, the Scientific Secretary of the Committee, at this Conference, to discuss with him the manner in which such co-operation might best be effected.

Entomological investigators in the West Indies have been considerably hampered by the difficulty in securing the identification of insects of economic importance, and also in obtaining necessary information with regard to the occurrence and control of insect pests in other countries; and it is absolutely essential to secure adequate assistance along these lines, if the colonies concerned are to reap the full benefits from the efforts of their scientific workers.

The far-reaching importance of entomology, with reference both to agriculture and public health, can hardly be overestimated, and in view of the difficulties referred to above, this Committee is of opinion that the suggested co-operation will prove of considerable practical value. As the Entomological Research Committee is in close touch with numerous specialists, and has ready access to all the literature contained in the libraries of the British Museum and other scientific institutions, it is in a position to render the assistance of which we stand in need. But in order to supply us with the information we require, it is recognised that the Entomological Research Committee will necessarily incur additional expense, and we urge that this should be met by contributions from the colonies concerned.

Mr. Marshall, proceeding, said that the method by which the Entomological Research Committee would deal with

any work coming from the West Indies had not been discussed by his Committee, but they had left him a free hand in making any suggestions that might appear feasible. It was of course difficult to estimate what that work was going to be; the greater the value of the Committee, the greater would be the amount of work thrown on the institution; but he suggested that the best way of dealing with it would be for the members of the Committee to appoint a Scientific Assistant whose work would be confined to dealing with questions affecting the West Indies. The insects sent in by them would be dealt with by him, and he would have to attend to all correspondence connected with them; and he (Mr. Marshall) estimated that could be done at an initial cost of £250 a year, so that this was the amount that he should suggest that the various Governments and administrations should consider whether they might see their way to contribute.

He might now say a word with regard to the work of the local entomologists in the West Indies. It seemed to him that they were working under considerable difficulties in many respects, and he was pleased to find what excellent work they were doing. He wished to draw special attention to the very valuable book which had just been brought out by Mr. H. A. Ballou.* which should be of very great practical assistance to the planters in controlling pests which caused them so much damage. He would like moreover, if possible, to see some attempt made to estimate in actual money the amount of damage that is being done to valuable crops in the West Indies by insect pests alone. He did not believe that the average man realised what it cost him. One would like to see more entomological work done. Persons who had to find the money in these colonies would say that there was a continual growing expense; but he believed that if they would try to ascertain what was being lost through damage by insects, they would open their eyes and would spend a little more money in combating these pests. There was another point. A suggestion had been made to him that he should submit some report embodying suggestions with regard to the work to be done in the West Indies. He must say that he had no knowledge of the insect pests of the New World. This was his first visit to the West Indies, and even if he were capable of doing so, he did not think it was the right thing to call in outside specialists to do work of this sort, and thus minimise the work of the local men. A man was brought out; he had no knowledge of the place; he had to pick the brains of the local men; and he got all the credit and they got none. The object of the Entomological Research Committee was not to do that. When the Colonial Premiers were at home last year, several members of the Committee met and discussed the matter, and it was suggested that they should form a central Bureau, similar to the Bureau at Washington, for the whole Empire. The principle involved was discussed, but the several details were not worked out; the matter was under the consid-

* Insect Pests of the Lesser Antilles, issued by the Imperial Commissioner of Agriculture.

eration of the Colonial Governments concerned. He hoped that it would be brought to a successful conclusion; the West Indies would derive more benefit than from the smaller scheme which he had suggested to them.

Sir FREDERICK J. CLARKE (Barbados): I have much pleasure in moving the adoption of the Report presented by Mr. Marshall. On the receipt of the despatch from the Colonial Office, to which Mr. Marshall has referred, the Government of Barbados appointed a Committee to consider it. I had the honour to be Chairman of that Committee, and on that Committee we had the Superintendent of Agriculture and other men in the Colony—physicians in practice and others who were likely to be able to give the Government the information they required; but I am afraid that, misunderstanding the purport of that despatch, we went on entirely wrong lines, and it has been a great pleasure to me to meet Mr. Marshall here and learn from him exactly what was intended; and I have no doubt that, now that the matter is understood, the Governments of these various Colonies will give substantial support to the scheme proposed by Mr. Marshall. I have not a word to say against the Bureau of Agriculture at Washington; as a matter of fact we all should be deeply grateful for the assistance that it has always been willing to render us. But I think that it is extremely humiliating for the Colonies of a great Empire to have to ask favours of a bureau of a foreign country; and if for no other reason than to save this humiliation that we have been subjected to all this time, we should give the support that Mr. Marshall has asked for the Entomological Research Committee.

Professor P. CARMODY (Trinidad): I have much pleasure in seconding that.

The Report was adopted unanimously.

REPORT OF THE NOMENCLATURE COMMITTEE OF THE AGRICULTURAL CONFERENCE.

Mr. G. A. K. MARSHALL next presented the following Report of the Committee appointed, at an earlier stage of the session, to deal with the question of unifying the nomenclature of the insect and fungus pests of plants known in the West Indies, with regard to which there is considerable confusion at present:—

A meeting of the Nomenclature Committee of the West Indian Agricultural Conference was held at the Queen's Park Hotel on Wednesday January 24, and on board the R. M. S. 'Balantia' on January 26, 1912.

After a preliminary discussion it was decided that, in order to obtain some degree of uniformity in the scientific and popular names of pests of the principal crops occurring in the several Colonies of the West Indies, the following recommendation should be put forward, namely that the Committee proposes that each colony should form a collection of the principal pests, to be sent in the first instance to the Imperial Department

of Agriculture with the scientific name and the popular name or names by which each may be known in the particular colony. The collection thus formed should be circulated subsequently among all the contributing colonies, in order that the specialists on the respective staffs may have an opportunity of forming an opinion on the various identifications. After this collection has been circulated, it should be returned finally to the Imperial Department in order that each agricultural department may receive specimens of every species contained in the collection, together with the scientific and popular names decided upon. Should any disagreement arise in this respect, it is suggested that in the case of zoological specimens the matter should be referred to the Entomological Research Committee of the Colonial Office, which would be requested to obtain an authoritative opinion; and in the case of botanical specimens, they should be referred to the Director of the Royal Botanic Gardens, Kew, with a similar request. Standard collections, in quantity, should be sent to the two Institutions mentioned, with a request that some of the material should be retained, in case any of the local Entomologists may later require further authenticated specimens.

This recommendation dealt with the establishment of a definite standard of nomenclature in the case of the material already available, and was agreed to by the members present, representing the colonies of British Guiana, Trinidad and Barbados, and the Imperial Department of Agriculture. In order to deal with any subsequent difficulties that might arise, it was suggested that the system proposed by Mr. Ballou should be adopted; namely that once in each year a letter should be sent from the Imperial Department of Agriculture to each of the agricultural bodies concerned, asking for any changes in names, or other alterations, which those institutions desire to make. On the receipt of the replies, a circular letter embodying all the suggestions should be sent to each of the bodies, asking for an expression of opinion as to the advisability of the changes put forward.

The proposer of any striking radical change should express clearly his reasons for it. The changes which meet with the approval of a majority of the bodies should be adopted, and the results of the voting should be communicated by letter to each, as soon as possible, so that the necessary changes can be made in their respective publications.

The various units represented by the members present at this meeting were: the Department of Science and Agriculture, British Guiana, with which it was hoped that the British Guiana Agricultural and Commercial Society and the Museum would co-operate; the Department of Agriculture, Trinidad; the Board of Agriculture, Trinidad; the local Department of Agriculture, Barbados; and the Imperial Department of Agriculture. It was proposed that the Department of Agriculture in Jamaica, and in Surinam, should be informed of the arrangment suggested, and should be invited to co-operate with the bodies referred to above, and that the Entomological Research Committee of the Colonial Office, and the Director of the Royal

Botanic Gardens, Kew, should be afforded definite detailed information of the system proposed, if it were finally adopted.

Further, that recognising the great advantage which accrues from the personal interchange of opinion between those engaged in the scientific investigation of insect and fungus pests, it was unanimously agreed that opportunity should be afforded for the Officers concerned to meet annually in each colony, in rotation, for the discussion of matters arising out of their investigations.

On the motion of Mr. H. A. BALLOU, seconded by Mr. A. P. COWLEY, this Report was also unanimously adopted.

USEFULNESS OF AGRICULTURAL CONFERENCES.

Mr. A. W. Hill (England) said that, when the President's invitation to this Conference was received by the Director at Kew, and he was delegated by him to attend, he looked forward to it purely selfishly as a botanist, with the keenest anticipation, as he felt that in this direction he was perfectly certain to have a most enjoyable and profitable time. As far as agriculture was concerned, he felt that he would have no right whatever to be invited to join in the deliberations of the Conference, and that probably the nature of the Conference would be such that he would not be particularly interested in the proceedings; but as was very often the case, preconceived opinions of that sort had to be altered and required modification, and he now felt that it would be unfair on his part to go back to England without expressing his feelings with regard to the extraordinary interest which he had had in all the affairs of the Conference. He had been very much impressed, both by the wide range and interesting character of the papers which had been brought forward, and by the keen and stimulating nature of the discussions to which they had listened. He had frequently found that conferences of this sort, and meetings of associations, at home, were regarded, by those outside the pale, as being in the nature of picnic parties and pleasure excursions, and so on. True, they had had their excursions and social gatherings, but he thought that it was largely in meetings of this character that one of the chief phases of the importance of the Conference existed. These Conferences afforded the best opportunities for social intercourse and discussions, and the bringing together of people of different views and different opinions; and rounded their corners and cemented friendships in a way that nothing else could do. It seemed to him, then, as one living outside the pale of this part of the world, that if the Imperial Department of Agriculture had done no other thing than arrange for the holding of these Conferences, it would have almost justified its existence. He was extremely interested in the work that was being done in the different islands which he had had the privilege of visiting. Some of the men in charge of the work were persons with whom, being men who were formerly at Kew, he was intimately acquainted; others it was not their good fortune to have had within their walls. But whether they were of one type or another, it appeared to him that the work which was being done was of the most laudable and valuable character.

It was an astonishing thing—it was characteristic of the English way of doing business—that they sent out men who, when they left home, were not particularly fitted for the work they were selected to do ; but when they arrived at their destination, they at once tumbled into it and produced excellent results. In every island that he had visited, and from what Mr. Marshall had told him, in the islands he (Mr. Marshall) had visited, all the work of the Botanic Gardens and Agricultural Experiment Stations was done efficiently and in an excellent way, and those engaged in it were taking the keenest interest in what they were doing. Going home from such an experience as that would be of enormous benefit to those delegates who had come from England, and interest in the West Indies would be spread, from Kew to Lancashire, and in all directions. In conclusion, might he again emphasize the importance of these Conferences in fostering a spirit of co-operation in scientific and agricultural work, and urge that every person in every way should try to keep an open mind as well as a critical spirit with regard to all new lines of work.

FORESTRY.

The President said that he had been directed by the Secretary of State for the Colonies to bring within the compass of the Conference, if it were possible, the subject of Forestry in the West Indies. Mr. C. S. Rogers, the Forest Officer of Trinidad, had prepared a paper on the results of his work in Trinidad, and members of the Conference would now be glad to hear from him something which would be helpful to officers in other Colonies. A paper entitled Forest Conservancy in Trinidad was then read by Mr. C. S. ROGERS, Forest Officer, Trinidad, and of this the following is an abstract :—

A brief review is given of the past history of the forests of the Colony, and followed by an account of the demarcation and plantation work accomplished during the last nine years.

Forest reserves having an area of 226 square miles, and with boundary lines totalling 452 miles, have been demarcated, and 85 acres of plantations have been formed since 1908. The trees which are being planted most extensively are cedar (*Cedrela odorata*, L.), cyp (*Cordia gerascanthus*, Jacq.) and to a less degree, Honduras mahogany (*Swietenia macrophylla*) and *Tecoma serratifolia*, Don.). The method adopted in planting has been to fell existing forest containing not more than 5 per cent of marketable timber, plant in lines 20 feet apart, and allow the secondary growth to come up between the lines, thus aiding the proper development of the trees and reducing the risk of damage by insect and fungus pests.

The paper concludes with a reference to the anticipated financial returns from the plantation work.

In relation to similar subjects, a paper entitled Memorandum on the Crown Lands in Dominica was prepared for the Conference by Mr JOSEPH JONES, Curator of the Botanic Station, Dominica. This is reproduced here in full, as its length is not such as to have necessitated the making of an abstract :—

The area of Crown lands under forest in Dominica is estimated by the Colonial Engineer at 60,000 acres. Forest

lands under private ownership are said to amount to 20,000 acres, making a total of 80,000 acres of forest, this presumably being land fit for cultivation if cleared. Sir Daniel Morris, in his report on Dominica, states the estimated area in swamps, rocky and other useless land as 46,000 acres. This gives an area of 126,000 acres of forest, 106,000 of which belong to the Crown out of a total of 186,000 acres.

The Dominica Forests Company has recently acquired rights over 12,500 acres of forest land, with the option of purchasing, as development work proceeds, a similar area, making a total of 25,000 acres.

In making grants of land the Crown now reserves: 'the exclusive use of a strip of the said lands thirty feet in width along each bank of all rivers and streams which flow through or along the said lands and all lands within a distance of two chains from and around any spring or from and around the source or feeder of any stream, or within three chains of the centre of any prominent ridge or dividing line of watershed.'

When it is considered that, in addition to the above, the mountain tops and their steep sides over an elevation of 2,000 feet are generally well protected by difficulty of access, and that cultivation is never likely to be carried on above 2,000 feet elevation, it does not appear that any further action on the part of the Government is necessary, unless it be to constitute all lands above an elevation of 2,000 feet or thereabouts a permanent Crown Reserve.

Another factor operating to maintain a forest area is the class of cultivation carried on, which is arboreal in character. If large areas of forest are cleared at any time, it will be for the reception of cacao, lime, or rubber cultivation. This means that a forest made up of many species is replaced by one or a single species. It is not anticipated that any change or adverse effect on the climatic conditions would follow such action, even when carried out on a large scale.

It would appear that the matter of forest control and conservation are by no means of pressing concern in Dominica, at present. With the possible exception of constituting a permanent forest reserve above a certain elevation such action as has already been taken by the Government appears to be all that will be necessary, for a long period.

After reference had been made by The PRESIDENT and by Mr. A. W. HILL to matters contained in the paper read by Mr. Rodgers, Dr. WATTS asked the reader of the paper if he had studied the question of the extent to which rubber and cacao plantations fulfil the functions of forests, as regards the conservation of water-supply. In reply, Mr. RODGERS stated that, inasmuch as a system of drainage is maintained in rubber and cacao plantations, such lands did not possess the effect in conservation known to be derived from the presence of forests: in the latter case there is no drainage, and a large part of the rainfall is held back to the leaves of the plants in the forest. After an observation by MR. NORMAN LAMONT, to the effect that the views put forward by Mr. Rodgers were supported by the report made in Trinidad by

Mr. Lodge, in 1900, Mr. RODGERS, in further reply to The PRESIDENT, stated that he had had no experience with Eucalyptus in the West Indies; he thought however that its propagation was advisble, in this part of the world, for the provision of fuel. Answering a further question from The PRESIDENT, Mr. J. JONES stated that there were about fifty species of Eucalyptus under experimentation in Dominica.

EXHIBITS AT THE CONFERENCE.

In addition to the exhibitions that were made of specimens and other illustrative material such as coloured sketches, maps and diagrams, during the reading of papers, an exhibit was placed, in the Conference Room, of other illustrative matter for use in connexion with several of the subjects that received attention. This included: bay oil samples, by Mr. W. Fishlock, Agricultural Instructor, Virgin Islands; cacao plants grown from seeds from fruits of different maturity, by Mr. H. Caracciolo, St. Joseph's Nurseries, Trinidad; cotton, commercial samples that had received report in England, by Mr. F. R. Shepherd, Agricultural Superintendent, St. Kitts-Nevis; cotton, Thornton's Hybrid, by Mr. T. Thornton, Tobago; insects, mounted specimens' showing the life-history of the principal pests of crops in Trinidad, together with illustrations of cases of remarkable insect structure, all set up in Ricker mounts, by Mr. P. L. Guppy, F.E.S., Assistant Entomologist, Board of Agriculture, Trinidad; millions (*Girardinus poeciloides*) from Barbados, for purposes of comparison, by Mr. H. A. Ballou, M.Sc., Entomologist to the Imperial Department of Agriculture; other, similar fish, including *G. guppyi*, *Haplochilus harti* and *Poecilia unimaculata*, by Mr. J. P. Guppy; rice, samples of different varieties, by Professor J. B. Harrison, Director of Science and Agriculture, British Guiana; root diseases, specimens showing, by Mr. F. W. South, B.A., Mycologist to the Imperial Department of Agriculture; sweet potato leaves, to show manner of classification, by Mr. W. Robson, Curator, Montserrat.

CLOSING OF THE CONFERENCE.

At 11.30 o'clock, His Excellency the Governor, Sir G. Ruthven Le Hunte, G.C.M.G., accompanied by His Excellency Sir. Bickham Sweet-Escott K.C.M.G., Governor of the Leeward Islands, and Lieutenant Le Hunte, arrived for the formal closing of the Conference.

On the announcement, by The PRESIDENT, that the time had arrived for the Conference to be closed formally, Mr. J. R. BOVELL asked leave to move the following resolution:—

'*Resolved*:—That the best thanks of the visiting delegates of the Agricultural Conference in Trinidad be conveyed to His Excellency the Governor, the Agricultural Bodies and the inhabitants generally for the great courtesy and kindness of which these delegates have been the recipients during their stay in this beautiful island.

'*Resolved*:—That the President of the Conference be asked to forward a copy of the foregoing Resolution to His Excellency the Governor, the Department of Agriculture, the Board of Agriculture and the Agricultural Society.'

Mr. J. W. McConnel: Mr. President—I have very great pleasure in seconding this Resolution. I feel it requires no words because we must all agree with it. I am exceedingly glad to have an opportunity of expressing my personal thanks, because I feel myself deeply indebted to everybody—from His Excellency the Governor down to every one of the people whom I have met and with whom I have made friends while I have been here. (Cheers.)

Sir Frederick Clarke: Mr. President—I cannot allow this Resolution to be put without adding something to what has been said by the Mover and Seconder. I want, on behalf of my colleagues of the island which we represent, to thank the people of Trinidad most sincerely for the very kind welcome and extreme hospitality which they have extended to us on our visit to their beautiful island. (Cheers.)

The President: Gentlemen, you have heard the Resolution, which I should like to endorse most cordially.

The Resolution was then put and carried unanimously.

Professor P. Carmody: Mr. President—It is perhaps most fitting that I should thank you for the vote of thanks that has been passed in connexion with the hospitality which the visiting delegates have received in Trinidad, representing as I do the head of the Agricultural Department. My experience of Conferences has chiefly been in the island of Barbados, and in our small attempts here at giving you whatever little attention it is possible for us to give in the space of time you have been here, we have only taken a short step toward working up to the measure of hospitality in Barbados. (Cheers.)

VOTE OF THANKS TO THE PRESIDENT.

Professor P. Carmody: Your Excellency, and brother delegates —I am asked to propose a vote of thanks to the President of this Conference. In doing this, I will ask you to consider the enormous amount of work that has fallen upon him before the Conference took place: the amount of organization, thought and consideration that has been necessary for collecting the scattered units of this Conference from different parts of the West Indies, from Surinam, British Guiana and England itself. That has been work entailing a vast amount of labour and consideration, and it has been done, as you know, with the greatest possible success. (Cheers.) Every arrangement has been made and carried through without a hitch. In connexion with the numerous papers which he has been able to present to the Conference, an enormous amount of labour has also been undertaken, to get the different members, scattered as they are, to prepare papers and bring them to the Conference in a state in which they could be fully discussed. That must have taken the President a considerable amount of time, and, I should say, work of stimulation, because there are a good many of us who require encouragement to produce a paper

at the present time. In connexion with all these functions, Dr. Watts has been with us, and has taken a part in everything that has been done during the Conference. This Conference, as you know, is the largest that has ever been held in connexion with agricultural matters in the West Indies. A much larger number of papers has been brought before the Conference than formerly, and they have been dealt with as efficiently as it was possible for any one to have done within the limited time at our disposal. It is not the President's fault that we can remain here only seven or eight days to deal with the papers. He is obliged to limit the reading of papers, but during the time when it was found possible for the Conference to hold excursions he has taken care that as many papers should be read on these excursions as was convenient. Former conferences held in the West Indies have been successful, but I think that you will agree with me that there has not been a Conference held which has been as successful as this, notwithstanding the large number of papers read. That is owing entirely to manner in which Dr. Watts has filled the Presidential Chair. (Cheers.) The Conference which is so near its close, has proceeded succesfully, without a single hitch. (Cheers.) I will mention this--I should have mentioned it before--that it is through the President that members of the Conference had an opportunity, on Saturday afternoon last, to visit a very historic place in this colony—St. Augustine—and the place where the tent was pitched on the Government Farm was near the spot where the capitulation treaty was signed in 1797, by which Trinidad became an English Colony; the house is supposed to be built on the very spot where the treaty was signed. I am sure you will all join me in passing a vote of thanks to Dr. Watts for the very admirable manner in which he has conducted the proceedings of this Conference. (Applause.)

Major the Hon. J. A. BURDON—Your Excellency, Mr. President, and Gentlemen—It gives me very great pleasure to be allowed to second the vote of thanks proposed by Professor Carmody, and to associate myself with him in all that he has said about our President. It gives me the chance of mentioning my sincere appreciation of the opportunity that this Conference has given myself, and all of us, of acquiring knowledge. I feel rather diffident in mentioning this point, owing to my own dense ignorance of all things scientific; but I have the temerity to believe that the profundity of that ignorance is in all fair way of being dispelled; I feel that my brain is now so crammed with knowledge, that some of it must stick. (Cheers and laughter.) It is true that most of the Latin names I have heard have taken to themselves wings (laughter), but I feel perfectly sure of my ground now when I speak disrespectfully of the Mendelian theory as applied to sugar-cane. (Laughter.) However, after all, it is not my duty to possess a knowledge of these Latin names; my duty is to assist those who do know them, to put their knowledge to the best possible use for the advantage and agricultural progress of the Colony in which I serve. I hope I have profited by the opportunities for improvement, so that when I return to Barbados I shall be able, more efficiently

than formerly, to grease the wheels of the agricultural coach. (Cheers.) The majority of you, Gentlemen, are grateful for the scientific results obtained from this Conference. I venture to hope that an increase in efficiency of the assistance rendered by the Government to agricultural progress may be found to be one of the practical results of this Conference. (Cheers.) And it is for giving us who are engaged in administration an opportunity for contributing toward that practical result that I, on behalf of my fellow administrative officers, desire to offer the President our most sincere thanks. (Applause.)

Mr. A. P. Cowley (Antigua): I do not think I should be doing my duty as a delegate of the Antigua Agricultural Society if I do not in some measure identify myself with the Resolution that has been moved. This Conference has been characterised by a feeling of good fellowship amongst all those who have come from England and the various Colonies; we have fraternised together, and we leave this island having made new friendships and new acquaintances as we have done on former occasions. but on a far greater scale. During this Conference, we have gone outside of agricultural matters and touched on subjects which have not arisen at other Conferences that I have attended.

His Excellency the Governor, in putting the Resolution on behalf of the President, observed that he need say nothing in addition to what had been said by the Mover and Seconder.

The Resolution was carried unanimously.

The President: Your Excellency and Gentlemen—I thank you very sincerely for the manner in which you have received the Resolution which has been submitted to you. It has been said on several occasions at this Conference that it is a larger Conference in point of number and in point of distance from which the delegates have come, and the largest in point of range of subjects with which we have dealt. We have gone outside the limits of pure agriculture at times, and I am not sure that a certain amount of presidential perturbation may not have been felt lest there may have been a little straying into difficult ground. Fortunately, notwithstanding the desire to lead ourselves a little way from agricultural matters, we have always found ourselves upon sound ground and have been able to return to the agricultural field without any damage to the Conference or ourselves, in consequence of our little wandering. You have alluded to the manner in which the affairs of the Conference have been successfully carried through. Certainly, I have had some work to do, but that work has been immensely lightened and made easier by the extremely active and unwavering support I have received from all the members of the Conference and very largely from the local Department of Agriculture, the local Board of Agriculture and others connected with agricultural matters generally, including the Agricultural Society. (Cheers.) I cannot allow this opportunity to pass without alluding specifically to the invaluable work done in this respect by Mr. Freeman, at the time Acting Director of Agriculture. (Applause.) I refer to him in his capacity as Acting Director of Agriculture, as in the capacity of Director I must include Professor Carmody, who was on leave just before

the Conference commenced its session. Mr. Freeman did an amount of work for which I am profoundly grateful, and the value of which, I am sure, is fully recognised by every member of this Conference. On all hands, we have received every kind of assistance needed for the Conference. We have received, first of all, the kind permission of the Chairman of the Board of Management of the Victoria Institute to take full charge of this Institute for the holdings of our meetings. Every institution in the island, both public and private, that thought it could in any way assist our work, our pleasure and our instruction, has come forward and done so in a way which is beyond all praise. From the Railway Department, the various Clubs, the Electric Car Company, the Royal Mail Company, the Management of the Victoria Institute, Mr. Cochrane and every agency in the place, I own to most generous support in enabling me to perform those duties which you say have been discharged in a manner to enable the Conference to be carried on successfully. I would like to think, and I am pleased to think, that we can look upon this Conference as the largest and most successful that we have had. There may have been defects and difficulties in the session, and additional matters that we should like to have accomplished, which owing to pressure of time and space we have been unable to carry out. There are many things which we ought to have done, and have not done through want of time. If the various Governments would give us a month for the Conference, we would do more work; but we cannot well do a month's work in seven days. I should not like to close without making specific allusion to the opportunity which was afforded to members of the Conference by the Agricultural Society of Trinidad and Tobago for being present at the private view and official opening of the Agricultural Exhibition. (Cheers.) I must also thank all the delegates from the other Colonies for the assistance they have given me in making this Conference successful. In conclusion, I feel unable adequately to express to Your Excellency my sense of gratitude for the kindness which you have displayed in enabling me to carry through this Conference, and I trust that those who may have future Conferences to conduct may find equally able and generous support, and meet with equal success—success which is entirely due to yourselves. (Applause.)

HIS EXCELLENCY THE GOVERNOR: The moment has now come when I have been asked finally to close this Conference, as I opened it, and in doing so, I can congratulate you, Mr. President, and all of you, on having made a success of it. It is a gratifying thing to you, and also to the people of Trinidad. In the name of the people of Trinidad, I thank you for the kind things you have said, and for your appreciation of whatever we have been able to do to make your stay and your work successful and happy. I am sure we are very glad to have the opportunity, at the last moment, of welcoming to the Conference His Excellency the Governor of the Leeward Islands. (Applause.) I am sorry he was not here to share with me the intense pleasure I have had in connexion with the Conference during the past week. I am very glad that the members of the Conference were able to witness the opening of our

Agricultural Exhibition, and I am sure you were pleased to notice the varieties of exhibits and the efforts made in so many directions for the advancement of agricultural industries. I am sure that the public, and especially the planters of the whole of the West Indian islands, will look upon this Conference and the work that has been done as of the greatest value. They will know that, whatever may be the matter with anything on their estates, they can turn with the utmost confidence to the scientists which this Conference has brought together. I have just received a despatch from the Secretary of State for the Colonies enclosing a report on samples of cotton forwarded by Professor Carmody, which I am sure those interested in cotton will be pleased to hear, especially Mr. Thornton of Tobago. It is a very excellent report, and I think you would like to know that the report on Tobago cotton is an extremely good one. (Cheers.) The Colonial Secretary of Barbados said just now that, after this Conference, he would be able to grease the wheels of the agricultural coach in Barbados. Well, if anybody in the West Indies ever wants a lubricant, they know where to go, in Trinidad, for oil. (Applause.) I now declare this Conference formally closed, and at the same time I wish to convey my sincerest congratulations to the President and everyone else connected with it, on its splendid success. (Great applause.)

[Pages 97 to 278, issued April 16, 1912.]

WEST INDIAN AGRICULTURAL CONFERENCE, 1912.

(CONTINUED.)

In the last number of the *West Indian Bulletin*, a summarized account was given of the papers and proceedings of the Conference held in Trinidad from January 23 to 30. The matter included abstracts of the papers that were presented, and it is now proposed to publish these papers in full.

CACAO.

SPRAYING CACAO.

BY JAMES BIRCH RORER, A.B., M.A.,
Mycologist, Board of Agriculture, Trinidad.

Although in temperate climates spraying has long since become a part of the routine work on almost every farm, orchard, and vineyard, in tropical countries, fungicides and insecticides are used scarcely at all; in fact the majority of planters have but little faith in such things, and even the mycologists and entomologists connected with the agricultural stations have made but few experiments to determine the real value of spraying in combating fungus and insect pests under tropical conditions.

From the close relationship of many of our parasitic fungi with those causing diseases of apples, grapes, potatoes and other northern crops, and the similar habits of many of our insect pests, it would seem very probable that the same means of control as are used in the North could be applied here. In order to ascertain whether or not this is true, especially with reference to the diseases and pests of cacao, a series of spraying experiments was

started on several estates in Trinidad two years ago, and some of them at least have been carried through to the present.

At the same time, a scientific study of the parasitic fungi and insects of the cacao tree was undertaken. I will merely mention in passing that, of the insects, the cacao beetle and thrips were found to be the cause of the most damage (Mr. Guppy will speak of these pests in detail later on), while of the fungus troubles, the canker and black pod-rot were by all odds the most serious.

For many years much confusion and doubt existed as to the cause of these diseases and each in turn has been attributed to a number of different fungi, but it is now well proved that both are caused by the same fungus, *Phytophthora Faberi*, Maubl. Both forms of the disease are so well known to those familiar with cacao cultivation that I will not take up your time in giving detailed descriptions, but these enlarged photographs (shown) will serve to recall to your minds the exact appearance of the diseases on pods and limbs. The first picture shows the course of the rot on the larger pods. The infection takes place generally either at the tip or stem end of the pod, and the fungus spreads very rapidly until the whole fruit is involved, and in the majority of cases it runs back through the stem into the tree and there produces the characteristic canker. The rot is at first brown and later becomes black. The fruiting threads of the fungus push their way out to the surface of the pods and produce spores in enormous quantities, especially if the weather is damp.

In the stem, the fungus is almost wholly confined to the bark tissues. The disease spreads in all directions from the point of first infection, but as a rule more rapidly in a longitudinal direction. The diseased tissue at first assumes what has been called a neutral tint, but later becomes claret-coloured and often exudes a blood-red, gummy liquid, especially in the rainy season.

That both of these diseases are caused by the same fungus, *Phytophthora Faberi*, has been amply proved by inoculation experiments with pure cultures. The following series of photographs (exhibited) shows the results of some of the inoculation work, while these specimens (exhibited) which were inoculated a few days ago show that the disease has already started.

In making the experiments in the control of these diseases the following plan was followed. A block of 1,000 trees was selected and divided into two equal parts, one of which was sprayed while the other was left unsprayed as a control. The two plots were as nearly alike as possible in all respects. The trees were of the same age, and the drainage, soil and shade conditions of each were identical. Before any spraying was undertaken, a record of pods yielded by each plot was kept. Each gave practically the same number. Some preliminary work which had been done on a smaller scale showed that it was perhaps best to spray the trees when they were well covered with young fruits. This was then done on the large plots and a second application was made from four to seven weeks after the first. Bordeaux mixture, made on the 4-4-50 and 5-5-50 formulae, was used. At the estate pickings the pods from each plot were collected, separated, counted and sorted into sound and black cacao. I will not trouble you with all the details of each picking on the different estates, but

will merely say that the results were much the same in all.* Not only was the amount of black cacao at picking time reduced, in some cases from 40 per cent. to 10 per cent., but—a fact still more noticeable—the yield in total number of pods was greatly increased by the spraying. In the two large pickings which were generally made from four to six months after the spraying was done the yield was fully one-third more from the sprayed trees. For example, in the Sangre Grande experiment 7,010 pods were gathered from the 500 sprayed trees, while from the adjacent 500 unsprayed trees 4,805 pods were gathered. During the whole year 3,390 more pods were picked from the 500 sprayed trees.

These figures show conclusively that spraying cacao does pay. Allowing the maximum cost for labour, materials, etc., to be one cent per tree per application, there was a net gain of over $20 from the 500 sprayed trees. Moreover, the whole benefit of the spraying cannot be readily reckoned in dollars and cents. It makes mossing unnecessary, and above all it prevents canker infection by protecting the pods; and there is no doubt that the diseased pods are the chief source of the disease in the tree.

In taking up spraying work it must not be forgotten that it is a preventive means of control, and to be effective must be done thoroughly and in good season, before the fungus has gained entrance to the pods. Moreover, adequate machines and properly prepared mixtures must be used. In recent years many substitutes for Bordeaux mixture have been advocated and we may try a number of them here; still, the copper mixture must be regarded as the leading fungicide, and it must be properly made from dilute solutions of good bluestone and fresh temper lime to give the best results.

In conclusion, you must remember that spraying does not put the fruit on the tree, and so to be of the greatest value it must go hand in hand with good cultivation.

FUNGUS DISEASES OF CACAO.

BY F. W. SOUTH, B.A. (Cantab.),

Mycologist and Agricultural Lecturer on the Staff of the Imperial Department of Agriculture for the West Indies.

INTRODUCTION.

The various diseases of cacao have been the subject of study in different parts of the world for the last quarter of a century, and numerous publications have been issued on the matter. The results obtained, however, while leading to a clear recognition of certain definite sets of external symptoms and of general methods of treatment of trees exhibiting them, were until the year

---

* The detailed pickings as well as methods of spraying are given in Circular No. 4, Board of Agriculture, Trinidad, 1911.

1909 decidedly unsatisfactory. This was due to the confusion which existed up to that date regarding the identity of the organisms primarily responsible for the damage in each case, and to the consequent doubt as to the number of diseases which existed, and as to their homology with one another in the different parts of the tropics.

In the year 1909, an important paper was published by Griffon and Maublanc[22] which showed, by comparison of specimens, that several fungi of the genera Diplodia, Botryodiplodia, Lasiodiplodia and related genera, found on the pods, stems and roots of cacao and on other host plants in different parts of the world, were in reality identical and belonged to one species, only; while as a result the range of host plants of this parasite had to be regarded as extensive. Subsequent work by Mrs. van Hall and Drost,[24] Petch[43] and Bancroft[6] confirmed these results. Furthermore, Petch[37] showed that a fungus known as *Botryodiplodia elasticae*, Petch, in Ceylon, and as *Diplodia rapax*, Massee, in the Malay States, and found to cause die-back of *Hevea brasiliensis*, is identical with the cacao fungus, as are in all probability certain other species, so that the number of host plants must be even further increased. Bancroft[6] determined the parasitism of the cacao fungus on Hevea and also described the complete or ascigerous stage of the fungus, thus making its determination a matter of far greater certainty, provided that his conclusions are correct.

An even more important step in advance was made in 1910, when Rorer[49] in Trinidad and Petch[39] in Ceylon published, within four months of one another, the results of their work on the relation between the most important of the pod diseases, long known in the West Indies as black rot and in Ceylon as brown rot, and the serious stem disease known as canker. The former author showed that both diseases of cacao were due to the same fungus, namely, *Phytophthora Faberi*, Maublanc, formerly known as *P. omnivora*, De Bary; and further that the numerous Nectrias, Calonectrias and allied species with various Spicaria and Fusarium forms found on cankered stems and diseased pods were only saprophytes, and as such were incapable of harming living tissues. The important conclusions resulting from this work will be dealt with more fully below. Petch's work completely confirms that of Rorer, and makes a further valuable addition to our knowledge, namely that the same fungus as causes canker and pod rot of cacao can give rise to exactly similar diseases in Hevea. It may further be noted that the discovery of the true cause of canker has necessitated the recognition of the fact that the disease can be produced by direct inoculation of healthy tissue, and that the presence of open wounds on the trees is not necessary for its entry.

This short outline of the principal work carried out during the last few years will suffice to show that a great increase has been made recently in our knowledge of cacao diseases, and it is intended to summarize the position as clearly as possible. To achieve this it is proposed to deal with the work in three sections, the first treating of the diseases individually in a simple and concise manner from the point of view of their symptoms and

treatment, and this will form the subject of the present paper. Other, subsequent papers will have relation to some general principles of sanitation on cacao estates, and to matters of a more purely mycological nature in relation to the identity, life-history and parasitism of the principal fungi causing the disease, as well as in relation to the nomenclature and identity of the more important saprophytes.

It may seem to some who have endeavoured to follow the rapid changes of position that have occurred recently, as regards the diseases of cacao, that there has been much unnecessary juggling with Latin names and that this can have no possible practical value. But a consideration of the summary given above may serve to show that this is not really the case, and that the apparent juggling with names has really given rise to some important results. One of these is that the recognition of the identity and directly parasitic action of the canker and pod rot fungus emphasized the importance of spraying with Bordeaux mixture as a preventive of these diseases, an indication which has been elaborated in the valuable series of experiments recently conducted by Rorer.[51]

Lastly, it may be pointed out that a certain amount of confusion exists in the popular names of cacao diseases as well as in those of their causative fungi. On account of this the generally prevalent names have been suggested, as in the list given on pp. 279 and 280. It is hoped that, as this revision of names was necessary, it may at any rate prove useful as a standard for future purposes and lead to a certain degree of precision in the popular nomenclature of cacao diseases in the West Indies Alterations in the scientific names of the causative fungi are due to several reasons which need not be enumerated here. Suffice it to state that they are usually beyond the control of individual workers not engaged at the time on a study of the fungi concerned, while in certain instances the work of such individuals themselves may bring to light facts necessitating an alteration in the systematic position of a fungus and consequently a change of a part or the whole of its name.

The revised list of cacao diseases together with the names formerly employed is as follows :—

Present Name.	Old Name.	Causative Fungus.	Cause formerly supposed* or former synonym†.
POD DISEASES.			
Phytophthora Rot ...	Black rot in the West Indies Brown rot in Ceylon	*Phytophthora Faberi*, Maubl.	†*Phytophthora omnivora*. De Bary
Thyridaria Rot ...	Brown rot in the West Indies	*Thyridaria tarda* Bancroft	*Botryodiplodia theobromae*, Pat. *Diplodia cacaoicola*, P. Henn. †*Botryodiplodia elasticae*, Petch *Lasiodiplodia theobromae* Grif. and Maubl., etc.

Present Name.	Old Name.	Causative Fungus.	Cause formerly supposed* or former synonym†.
Anthracnose	...	*Colletotrichum* sp.	...
Jamaica Pod Disease	...	*Colletotrichum Cradwickii*, Bancroft	... ...
Hardening of Pods ...	...	*Colletotrichum luxificum*, van Hall and Drost	...
Blackening of Beans (San Thomé) ...	...	*Acrostalagmus Vilmorinii*, forma *Thomensis*, Guéguen	...
STEM DISEASES.			
Canker	...	*Phytophthora Faberi*	***Nectria* spp. *Calonectria flavida* Massee, etc. *Spicaria colorans*, A. E. van Hall
Chupon wilt	...	*Phytophthora Faberi*	...
Die-Back ...	...	*Thyridaria tarda*	†*Diplodia cacaoicola*
Stem Disease ...	...	*Thyridaria tarda*	†*Lasidiplodia* sp. etc.,
Witches' Broom and Star Bloom (Surinam)	...	*Colletotrichum luxificum*	**Exoascus theobromae* Rit. Bos.
Witches' Broom (Cameroons)	...	*Exoascus Bussei*, Von Faber	...
Pink Disease	...	*Corticium lilacino-fuscum*, B. and C. (West Indies) *C. javanicum*, Zimm. *C. salmonicolor*, B. and Br. (Eastern Tropics.)	...
Thread Blights ...	...	Various prob. near genus, *Hypochnus*	...
Horse-hair Blight ...	...	*Marasmius equicrinis*, Müll. (West Indies.) *M. sarmentosus*, Berk. *M. rotalis*, B. and Br. (Eastern Tropics.)	...
Flowering Disease and Male Cacao ...	...	Cause uncertain, poss. *Colletotrichum* sp.	...
SEEDLING DISEASE.	...	*Ramularia necator*, Massee, etc.	
ROOT DISEASES.			
Thyridaria Root Disease	Root Disease	*Thyridaria tarda*	†*Macrophoma vestita*, Prill. and Delacroix *Lasiodiplodia* sp. *Lasiodiplodia theobromae*
White Root disease ...	Root canker (Grenada)	Unidentified	...
Black Root disease ...	...	*Rosellinia* sp.	...
Brown Root disease... (Eastern Tropics, etc.)	...	*Hymenochaete noxia*, Berk.	Identity uncertain

Besides these, there are a few other fungi parasitic on the cacao tree but not of any great importance as yet. They, together with certain saprophytic species, will be referred to when the time comes for dealing with the more strictly mycological part of the subject.

POPULAR DESCRIPTIONS OF THE DISEASES.

POD DISEASES.

PHYTOPHTHORA ROT. This disease, formerly known in the West Indies as black rot and in Ceylon as brown rot, is found in practically every country where cacao is grown. It occurs on pods of all ages and is by far the most important of the pod rots, not only on account of the harm it inflicts on the pods themselves, but also because the causative fungus can spread from the pods into the cushions and give rise to canker, while spores of the fungus produced on the pods can apparently bring about canker of the stem by direct infection. Thus the presence of the diseased pods is a direct menace to the actual life of the trees.

Another interesting point is that a disease of the fruits of Hevea trees of a very similar nature is caused by the same fungus in Ceylon, and that it is also accompanied by canker of the stem produced by this organism, though in the case of the rubber tree the canker does not arise through the spread of the fungus mycelium from the fruits into the main stem, but is the result of direct infection by spores only. It may be noted that this fungus, though found on stems and pods, has never yet been authentically recorded on the roots of cacao, except when they project above the soil. It is clear that, since two important diseases of cacao and of Hevea are due to one fungus, the interplanting of these crops should be carefully avoided. This is particularly the case because in such a mixed plantation the atmosphere is damper than where one crop is grown alone, and thus the growth of the fungus is favoured.

The symptoms of this rot are well known and need only be recapitulated very shortly. On young pods it appears first as a small black spot occurring anywhere on the surface of the pod. This spreads rapidly and the pod becomes black, shrivelled and dry within twenty-four to forty-eight hours. On larger pods, half or full-grown, it is first seen as a slight brownish discoloration which is usually at one or other of the ends of the pod, but may be anywhere on its surface. This spot spreads rapidly and, when the infection has commenced at one end, the line of demarcation between the healthy and diseased tissues often forms an almost horizontal ring round the pod. This line, though definite on the surface, does not occur in the internal tissues. When the pod is half-grown the mycelium of the fungus rapidly penetrates the beans which are then closely pressed against the inner surface of the shell; when the pod is ripe and there is a space between the shell and the beans, the latter may not become affected for some time.

After a few days the pod becomes brown all over, and is covered with white powdery masses of spores; various saprophytic fungi then intervene and envelope it with a white mould. The whole pod eventually rots away in wet weather, while in drier

weather it becomes black and shrivelled, and remains hanging on the tree.

The disease is due to a fungus now known as *Phytophthora Faberi*, Maubl. It is closely related to *P. omnivora*, De Bary, to which species the disease was originally attributed by Massee [32] who examined specimens from Trinidad. Its sporangia require the presence of a considerable quantity of moisture to enable them to germinate; consequently the disease is more prevalent in the rainy season and on cacao grown in low-lying, damp, badly drained situations, or in fields where planting has been too close, or where there is too heavy shade. The oospores, or resting spores, are formed inside the tissues of diseased pods, so that the latter are a source of danger even after the conidia, or more rapidly germinating spores, have disappeared from their surfaces.

Infection may take place by the germination of a sporangium on the surface of the pod, that is it may be direct; or the fungus may spread into the pod from a cankered cushion that has become diseased previously, owing to the spread of the fungus back into it from a pod borne during a preceding crop. When more than one diseased pod occurs on a cushion, there is considerable probability that the cushion is the source of infection, provided that the disease commences at the stalk end of the pod.

There is no remedy capable of stopping the spread of the disease in an infected pod, and, in consequence, methods of combating it are entirely of a preventive nature.

The most important measure of this kind is the thorough spraying of the trees at the right time of year with Bordeaux mixture, as it not only reduces the number of diseased pods, but has a cumulative effect on the prevalence of canker. This measure has been found to pay satisfactorily in the experiments conducted by Rorer [57] in Trinidad, and experience with diseases of temperate fruit trees would seem to indicate that it is likely to prove the most useful preventive that can be employed. It has been usual to recommend the destruction of infected pods, but Rorer [49] points out that the rapid development of the fungus is likely to render this measure of little avail, while in that case its cost would be considerably greater than the increase of profits attending its employment. The usefulness of this measure is, however, open to discussion, as it is still recommended by Petch [37] in Ceylon, while it would seem that little time would be wasted if pickers were instructed to remove all diseased pods, of whatever age, in the usual course of their work. Careful attention to drainage and to planting distances, and the avoidance of excess of shade are also of importance in combating this disease.

Finally, it must be borne in mind that the more delicate varieties of cacao are decidedly more susceptible to infection by Phytophthora rot than is the Forastero. This seems to depend partly on the nature of the more delicate varieties themselves, and partly on the fact that they require more shade. Trees of the Forastero variety grown in damp situations are more susceptible to the disease than those grown in dry localities, though less liable to infection than the more delicate varieties grown under similar damp conditions. Where Forastero cacao

can be grown without shade, as for instance in Grenada, Phytophthora rot and canker, though always present, do not cause any very serious loss.

THYRIDARIA ROT. Like the disease that has just been described this, known in the West Indies as brown rot, occurs in almost all countries in which cacao is grown. It is, however, probable that the damage due to it is not nearly so extensive as that caused by the Phytophthora, even when one takes the pods alone into consideration, while it is also probable that some at any rate of the harm attributed to it was in reality due to the presence of Phytophthora rot, or of anthracnose on the pods examined. Recent observations have shown that this disease is confined almost entirely to pods that have been injured in any way, or to those that are over-ripe; it practically never appears on healthy pods. Thus though it occurs on nearly every damaged pod, its importance has certainly been over-estimated in the past.

The symptoms of this disease are in their early stages very similar to those of Phytophthora rot, though in a more advanced condition they differ somewhat. They are as follows: A small, brown, almost circular spot appears first at either end of the pod or along one of the grooves, if the pod is over-ripe; if the pod is injured the disease always commences at the injury. Cuts into the stalk made by pickers often serve as an entry for the fungus, and in these cases the rot first appears at the stalk end. This brown decay spreads rapidly all over the pod, destroying the rind. Subsequently it penetrates into the centre of the pod and destroys the cacao beans, which are enveloped by a greyish-brown mass of fungal mycelium. The pods are usually soft and rotten, and eventually fall from the trees, or dry up and remain hanging. On the brownish-coloured diseased areas small pustules may be seen bursting through the rind of the pods and giving the surface a roughish appearance. They emit a dark tendril in damp conditions or, under dry conditions, a greyish, white powder. This consists of a mixture of unicellular, colourless and bicellular brown spores of the Diplodia stage of *Thyridaria tarda*; the colourless unicellular spores are immature and become brown and bicellular on ripening; both forms however will germinate if placed in water, or in suitable damp conditions. The whole pod is eventually blackened, owing to the presence on its surface of the mature spores given off from the numerous pustules. This later stage of the disease is readily distinguishable from Phytophthora rot by the rough appearance of the surface of diseased pods, and by the presence of the dust of spores.

The disease is due to the conidial stage of a fungus whose complete ascigerous form was recently described by Bancroft [6] as *Thyridaria tarda*; the conidial stage has long been known locally as *Diplodia cacaoicola*, though it has numerous synonyms, among which the best known are *Botryodiplodia elasticae*—the name by which the fungus was first known in Ceylon, and *Lasiodiplodia theobromae*—the name most commonly used in recent publications. The fungus can live as a saprophyte on any cacao material and on many different host plants. It is a wound parasite on cacao twigs, where it causes die-back, on cacao stems and roots. It is also found as the cause of die-back on Hevea in

Malaya, and on the same host plant in Ceylon, where it follows the attacks of *Gleosporium alborubrum*. Petch, on the young twigs. Its numerous other host plants will not be emunerated here.

This disease can be prevented to a great extent by attention to general estate sanitation, that is, to drainage, pruning and the safe disposal of broken husks and decaying twigs lying in the fields. Pickers should be taught to work with great care and should be provided with suitable knives in order to prevent as far as possible the infliction of injury on stalks of young pods or on the pods themselves. There is no doubt also that spraying with Bordeaux mixture, exactly as in the case of Phytophthora rot, would have a very beneficial effect in reducing the prevalence of this disease and of the other diseases due to the same fungus.

ANTHRACNOSE. This is a disease, that, so far as the writer is aware, has not yet been definitely described, though a passing reference to it is made by Rorer [50], from Trinidad. It still requires much investigation, but is included here as being possibly of some importance and almost certainly a specific disease. Its distribution is uncertain in the West Indies, but it is probably of fairly general occurrence throughout the islands. As regards its occurrence in other parts of the world, there is considerable uncertainty at present, since the causative fungus has not yet been definitely identified, but possibly it is the same as a form of disease described from the Cameroons by Busse [13].

As far as present observations go, infection usually shows itself in the form of small spots on the surfaces of the fruits, which may be of any age. These spots are at first moderately light-brown in colour, but later become darker and are sunken below the general surface level of the pod; they are usually limited in extent and irregular in outline, while the tissues in the centre of the spots become hard and dry. The tissues of the rind below the spots are brown and diseased, and the causative fungus penetrates as far as the beans. When the spots are commencing to dry, small yellow pustules not as much as 1 mm. in diameter, break through the epidermis. These are closely crowded and become pink as they develop, so that the centres of the spots are covered with an almost continuous pink coating consisting of millions of small, colourless, unicellular, hyaline spores belonging to a species of Colletotrichum. In some cases the spots fuse with one another and produce large discoloured areas, while in extreme cases the whole pod may become discoloured and practically completely destroyed; this is especially the case with young pods. A similar appearance of spots on the surface of cacao pods was described by Stockdale [52], under the name Scabby Pod, and was attributed by him to *Lasiodiplodia* sp.; but his investigation was not completed. For various reasons it seems probable that he was mistaken in his opinion of the cause of the disease, or perhaps was only dealing with an early stage of Thyridaria rot.

The identity of the Colletotrichum has not yet been definitely established, though it appears very similar to *C. theobromicolum* found by Delacroix [16] on cacao fruits from the West Indies, and to *C. incarnatum* found on pods attracked by Phytophthora rot in Ceylon [40]; and on diseased pods in Java [57] and the Cameroons [13];

it also resembles *C. Cradwickii*, found by Bancroft[4] on cacao pods from Jamaica. The same or a closely related species occurs frequently on decaying cacao pods as a saprophyte. The anthracnose fungus appears to be a direct parasite, as the spots may occur anywhere on the surface of the pod and are independent of the presence of wounds. The disease is not of much importance in itself, but it seems likely that it affords a means of entry for the Thyridaria rot. It could probably be controlled by spraying if it ever became of importance. In any case, spraying for other diseases would reduce the prevalence of anthracnose.

JAMAICA POD DISEASE. This was described by Bancroft[4] under the title A new West Indian Pod Disease. It occurred on pods of cacao forwarded to Kew from Jamacia. Some of the pods examined were also attacked by *Thyridaria tarda* and *Phytophthora Faberi*, referred to by Bancroft as *Diplodia cacaoicola* and *P. omnivora.* No inoculation experiments could be conducted, so that it is not certain that the third fungus found on the pods is a direct parasite. This is a species of Colletotrichum said by Bancroft to be new and called *C. Cradwickii.* It is similar in some respects to the anthracnose fungus.

The infected pods were small and very hard, and showed here and there groups of the fructifications of the fungus. These burst through the rind as pustules, at first yellow and then pink. The hyphae of the fungus penetrated the pods, and were found in the mucilagenous covering of the seeds. The disease does not appear to be of a serious nature and hardly requires the employment of preventive measures. Probably, if necessary, spraying with Bordeaux mixture would assist in controlling the disease.

HARDENING OF PODS[25]. This is a disease of pods caused by the presence in their tissues of the fungus responsible for the witches' broom disease of Surinam. The disease appears on pods of all ages and may have one of three distinct forms. In the first, the chief symptom is a swelling of the pod stalk ; this may be so extensive that the epidermis of the stalk is ruptured in consequence. In the second, humps and curious malformations appear on the pods themselves. The tissues of these humps are shorter-lived than healthy tissues, and on being cut through show brown streaks of dead cells. Such pods do not ripen, but drop before they are half grown. The third form occurs on pods that are ripening or are nearly ripe. On pods that are green, yellowish-green discolorations appear as fair-sized spots. On yellow pods the spots remain green. The diseased tissues soon die, and their colour becomes brownish and then black. On red pods the infected area remains greenish, never acquires a deep red tint and finally turns black. The black spot is very hard and when it spreads, as it may do under damp conditions, and envelopes the whole pod, the latter becomes hard all over. The hardness distinguishes this form of pod disease from Phytophthora rot. Inside badly attacked pods, a number of beans disintegrate and form a mucilagenous mass in which the remaining beans often germinate. At other times, especially during the rainy season, the soft portions of the fruit become watery, and the kernels lie loose in a somewhat slimy fluid and fall out when the pod is broken.

The hardening is caused by *Colletotrichum luxificum*, the fungus to which the witches' broom disease of Surinam is now attributed. Its treatment will be considered under the heading of the latter.

BLACKENING OF BEANS. This is a peculiar disease which attacks the covering of the ripe beans, either when they are still inside the pod, or when they are in the storing house. It occurs at present only in the island of San Thomé, and was described by Guéguen [28] in 1909 from specimens sent to him from that place.

Certain ripe pods possess a peculiar vinous smell, and on opening them it is seen that a growth of mould, sometimes dirty white, sometimes greenish-black in colour, has covered the placental column, the inner wall of the pod and the covering of the beans. In the store-house a few such infected beans in a heap act as a source of infection which brings about the rapid destruction of the whole heap. In addition to the fungus, narrow tunnels are usually found in infected pods, which penetrate the wall directly and are continued into the radicles of the beans. It should be noted that the beans are so arranged in the pod that the radicles all face the outside. The opening of a tunnel on the surface of the pod is always directed opposite a radicle, and the tunnel always runs in along the shortest path to the radicle into which it is continued. The tunnels are made by the shot borer beetle, *Xyleborus perforans*, well known in sugar-cane growing countries. The larvae of this insect penetrate the pod and eat the radicle, but do not touch the cotyledons. In doing this they introduce the mould fungus that destroys the beans. In a few instances pods with diseased beans had not been pierced by the beetle. Guéguen suggests that in these cases the fungus may have commenced to grow on the style and have entered the pod along the stylar column.

The fungus itself is a form of *Acrostalagmus Vilmorinii* called by Guéguen forma *Thomensis*. Its mycelium is white when young, greenish-black when old, and it reproduces itself by means of spores, which are formed in large numbers, and also by specialized portions of its mycelium.

Guéguen suggests that spraying the pods when they are just formed, and again when they are from one-half to three-quarters grown, with a solution of arsenite of copper, rendered more adhesive by the addition of molasses, would probably serve to control the disease in the field. At the same time a careful watch might prevent the introduction of diseased beans into the heap in the storing house, and thus obviate the losses occasioned in this way.

In concluding the account of pod diseases, mention may be made of a peculiar appearance that is due to the damage caused by thrips (*Heliothrips rubrocincta*). When these insects attack nearly full-grown pods the well-known rusty-brown colouring is the result. When the attack is severe the epidermis may die and become dry and black, at any rate in places. If this occurs before the pod is full-grown, the tissues immediately beneath the surface give rise to a thin layer of cork which, according to Howard [29], is in reality a new epidermis. As the pod continues

its growth, the dead, dry epidermis splits both longitudinally and transversely and then remains adhering to the pod in rectangular patches about ½-inch or less square, separated from one another by strips of healthy tissue somewhat rough on the surface and of varying width. Such pods may be found probably in any island as a result of attacks by thrips, but they have been specially noted by the writer in St. Vincent where they are known as 'scabby pods'. They may be distinguished from pods affected by true fungus diseases, on account of the fact that the surface discoloration does not extend to the inner tissues. *Colletotrichum* sp. and *Thyridaria tarda* often develop on such pods, especially when these are kept in the laboratory, but they are not the true cause of the disease.

STEM DISEASES.

CANKER. This malady, largely dependent as it is on the occurrence of Phytophthora rot of pods, must be regarded as by far the most important stem disease of cacao. It is universally distributed throughout the countries in which cacao is grown, and has been known for many years, the first record of serious damage caused by it being probably as far back as the eighteenth century. Notwithstanding this, nothing was done towards its investigation until the year 1898. At that time Carruthers [14] commenced his investigations in Ceylon; while Hart [26,27] and others, assisted by Massee [35] at Kew, made some observations on it in Trinidad. Subsequently, other workers gave it attention in various parts of the world, with the result that its symptoms and treatment were generally known at the beginning of the twentieth century. As regards its cause, however, there was much uncertainty. Several different species of fungi, particularly of the genus Nectria, were found on the diseased bark and were regarded as the cause of the disease in different parts of the tropics. This led to much doubt as to the homology of the diseases described, and it was usually thought that they could not be all of the same origin. In 1905 Busse [13], in the Cameroons, noted the occurrence of *Phytophthora* sp. both on pods and on diseased bark, and it was proved by Rorer [49] and Petch [39] in 1910 that this fungus now known as *Phytophthora Faberi* is the true cause of the disease.

Trees that are badly attacked by canker may usually be identified by their general sickly appearance, manifested by the presence of dead branches, small, somewhat yellow leaves, numerous black pods and suckers dying from the base upwards. In the early stages, however, these symptoms are absent, and the cankered areas themselves are difficult to locate. The surest method of finding them is by cutting into cushions bearing pods affected by Phytophthora rot, particularly when these are rotting from the stem end; if this is done it is found that, either the cushion and the surrounding bark are cankered, or that fine strands of diseased tissue lead to a cankered area. Moreover, in the rainy season, a cankered patch may often be discovered owing to the fact that it does not dry as fast as the surrounding healthy bark; when dry such spots may have a peculiar greyish-brown appearance. At a later stage, the bark cracks and exudes a

brownish-red gummy fluid which gives the bark a rusty appearance when it dries. Such exudation may also occur when diseased bark is penetrated by boring insects. In this bleeding stage the disease is of course quite noticeable, but it is desirable to discover it long before this.

On removing the outer bark from a cankered region, it is seen that the inner tissues are of a dark claret or of a neutral brown colour and are generally separated from the healthy yellow or pink-coloured tissues by a narrow black line of cork cambium. Such diseased tissues are moist and soapy to the touch. On cutting deeper into the bark, the discoloured area is often found to be larger in extent than was at first expected, as the disease spreads in the inner layers, in the cambium or possibly even in the outer layers of the wood. The fact of the penetration of the wood is, however, somewhat doubtful.

The treatment of this disease is of two kinds, remedial and preventive. The remedial measures are as follows: The cankered areas must be carefully excised, preferably with a chisel. Every portion of diseased tissue must be removed and all the chips must be burnt. The wound must then be dressed with coal tar, or preferably, perhaps, with resin oil. If it is desired to indicate what wounds have been treated and what have not, a mixture of 1 part of tar to 4 parts of oil may be employed. These measures aim at preserving the life of trees already attacked, and constitute the only known method of achieving this end. If left to themselves, cankered trees will usually die, as the disease spreads and eventually rings the trunk. The preventive measures consist primarily of spraying trees with Bordeaux mixture so that infection, particularly through the pods, is obviated. Collection of diseased pods and their careful burial also exercise some restraining effect upon the spread of canker, but the feasibility of this course is open to question. The prompt treatment of actually infected trees is another point of importance, as if it is neglected the disease in them spreads to the pods, on which numerous spores of *Phytophthora Faberi* are produced, and these give rise to further infection. Again every effort should be made to keep the conditions as dry as is consistent with the growth of the trees. For this reason planting distances should be wide and shade where necessary, should be as light as possible and of an overhead nature. For the same reason, as is stated in connexion with Phytophthora rot, interplanting of cacao and rubber must be avoided. It must be remembered that preventive measures, particularly the application of Bordeaux mixture, aim only at protecting healthy trees or parts of trees from infection and can have no effect on the spread of the disease in infected tissues.

CHUPON WILT. This disease was first described from Trinidad by Rorer[49] and has apparently not been previously noted, so that nothing is as yet known of its distribution in other cacao-growing countries or in any of the other islands of the Lesser Antilles. It is discussed in this place because it is due to the same fungus (*Phytophthora Faberi*) as are canker and pod rot.

Rorer describes the disease as follows: 'The chupon is generally first attacked in the soft tissues near the tip. A small water-

soaked area can be seen on the stem which gradually becomes sunken and darker in colour and spreads up and down the stem frequently girdling the shoot and causing the upper part to wilt. The same disease has been observed on young shoots on the upper branches of the tree. The point of attack is generally in the axil of a leaf, though the leaf blade or petiole may be the first part affected, the disease afterwards running down into the stem.

'Chupons are also frequently killed by aphides or other sucking insects, and such should not be mistaken for the disease of fungous origin. The final appearances of the killed shoots are the same but the initial stages are quite different.'

Measures directed towards the control of canker and pod rot will have a concomitant effect on this disease.

DIE-BACK AND STEM DISEASE. These two forms of disease are due to one fungus—*Thyridaria tarda*—that has already been referred to as causing one of the pod rots. Both are to be found in all countries where cacao is grown, while in the past it was considered that much very serious damage was attributable to them, and that they might even form a menace to the cultivation of this crop. Barrett [10] went so far as to say that by far the greater proportion of the damage inflicted on trees in Trinidad was due to *Lasiodiplodia* sp., now known to be identical with *Thyridaria tarda*. Recent work has shown, however, that in all probability this organism is not primarily responsible for much of the harm once attributed to it, while in another direction proof has accumulated that both diseases are easily controlled by careful attention to general sanitation, drainage and manuring. Nevertheless, although an epidemic directly due to this fungus is unlikely to take place, yet its occurrence as a saprophyte or wound parasite on a large number of different host plants renders it worthy of attention.

Cacao trees growing in situations exposed to wind or sun, or where the drainage is bad or the soil very poor, or where any such causes are responsible for a sickly condition of the plants, may exhibit a progressive dying back of the tips of the branches. The latter become dry, and the bark turns dark-brown or nearly black, while the wood on examination is found to be grey in colour. On splitting such a twig longitudinally it will be seen that the diseased tissue passes over gradually through an unhealthy strip into the healthy portion, and that there is no definite line of demarcation between the two, such as occurs when the death of the twig is due to exposure to wind or sun alone. This condition is due to the presence in the tissue of the mycelium of *Thyridaria tarda*. The fungus spreads in the cambium and outer layers of the wood, and afterwards invades the bark. About 3 inches behind the advancing margin of the disease, the black pycnidia of the Diplodia stage may be found as small lumps breaking through the bark. If such trees are left to themselves the fungus will gradually spread right down them and destroy them completely.

It should be distinctly understood that the fungus is unable to obtain a hold except on twigs that have died from some other

cause, or have wounds on them that expose the cambium and the wood. It seems, from Bancroft's [6] work with this fungus on Hevea, that slight abrasions involving the bark only are not likely to afford the fungus a starting place. Even if dead twigs are present, it is probable that the fungus would be unable to spread from them sufficiently far to cause much damage, if the trees were otherwise in good health and well cared for.

Another form of damage to sickly trees is caused by the attack of the same fungus on older portions of the stem and branches. It gains an entrance through wounds exposing the wood, such as are afforded by untreated pruning wounds, old cankered areas, chance cuts made with a cutlass or with a picking knife and the like. In this case the fungus may spread around a large limb and cause its death, or may run down the trunk and kill the whole tree. As in the case of die-back the bark becomes dry and dark in colour, while the wood is dry and discoloured grey. It should be noticed that this form of the disease was attributed by Stockdale [52] to *Lasiodiplodia* sp., a fungus believed by him to be different from the *Diplodia cacaoicola* stage of *Thyridaria tarda*. Subsequent work has shown that the two forms are in reality only one fungus.

Preventive measures against this disease consist of the careful removal of the infected parts. Twigs or limbs of the trees should be cut off at a considerable distance, from 3 to 6 inches beyond the advancing margin of the disease, that is, beyond the point at which the wood shows the first obvious symptoms of attack. Where the stem is attacked, excision, as in the case of canker, is the only course to be adopted; though if the disease has spread to any great extent, it might well be preferable to remove the tree and replant, since excising the amount of wood necessary to ensure the complete romoval of the fungus would very possibly weaken the tree to such an extent as to render it very liable to be blown over, and at the same time might excessively reduce the amount of water-conducting tissue.

On estates where the diseases are at all wide-spread, they may be brought under control by attention to the remedial measures already referred to under the headings of Phytophthora and Thyridaria pod rots. These, as has been indicated, involve careful attention to general sanitation, especially to pruning and the treatment of the resulting wounds; to protection of the trees from wind; and to drainage, manuring and mulching. On a well conducted cacao estate the amount of loss due to these forms of disease may be reduced almost to nothing.

WITCHES' BROOM DISEASE. Two diseases to which this name has been given are known. One has been noted for many years in Surinam, where it has caused much damage, and has been more recently recorded in Demerara; the other was first recorded by Busse [13] and subsequently described by von Faber [17] from the Cameroons. As the two diseases differ in symptoms and in origin, they will be dealt with separately.

The Surinam disease is due to the attack upon the young buds of a fungus called by van Hall and Drost [25] *Colletotrichum luxificum*. The parts affected may be either flower buds or vegetative buds, and in the latter case, either terminal or lateral,

A different manifestation of infection takes place in each case, though hypertrophy, that is excessive and abnormal growth of the tissues, is a constant character in all. Furthermore, the disease may attack the pods and cause loss in that manner; this case has already been considered under the title of hardening of pods. The different forms of the malady cannot be considered here, for these reference must be had to the original paper by Dr. van Hall and A. W. Drost which has been translated into English by Dr. Fredholm and published by the Agricultural Society of Trinidad and Tobago. A short account of the appearance of the two typical forms of the disease, namely witches' brooms and star blooms, may, however, be given together with a short account of the remedial measures advised. The description of the typical witches' broom of cacao, as given in the English translation of the original Dutch paper already referred to, is as follows: 'It is generally two to six times as thick as a healthy twig, its surface is rough and somewhat furrowed, its base turgid, at times exhibiting longitudinal corrugations. The leaves do not become fully developed but remain soft and flimsy like recently unfolded leaves on sound twigs, often they are of a dark colour. Among other characteristics of witches' brooms should be mentioned the bending over of axillary buds, even before the witches' brooms are fully developed, the strong tendency to produce side-shoots, the retention of the supporting leaves, the growth of shoots in a vertical direction and the short life-time.' It may further be noted that these growths, from their erect habit, appear like epiphytes on the trees, the component branches are always devoid of bark and thus resemble suckers, while their life-time is never more than a couple of weeks. These growths may originate from buds on young branches and twigs, in which case they are vegetative shoots; or they may arise on older branches or the main stem, when they must be regarded as abnormal growths of buds intended to produce flowers. In this latter case the witches' broom itself may bear a few flowers, though these always have over-developed sepals and petals and almost abortive ovaries. This production of flowers is unknown in the case of any other form of witches' broom on other hosts, and further serves as one of the distinguishing features between the Surinam disease and that described from the Cameroons.

When a flower-bearing cushion is attacked, the disease may take a form different from that just described. Instead, a condition known as star-blooms may result: it is described, in the reference given, as follows: 'The symptoms consist in the production of a great number of crowded blossoms formed either on individual stalks or from lateral ramifications of an enlarged fruiting branch. Vegetative shoots developed into small witches' brooms are frequently found among the flowers. Cushions from which star blooms proceed are generally somewhat tumid.' Such blooms rarely produce full-grown fruits, but usually give rise to a few mis-shapen pods containing no seeds. This condition is known in Surinam as male cacao and recalls a similar condition often found in the British West Indian Islands. The cause of the appearance in the islands is, however, certainly different, though not definitely determined as yet.

It will be seen from this short discussion that the disease injures the trees and reduces the crop in three ways. The production of many of these rapidly growing witches' brooms exhausts the reserve food-supply; the infection of the cushions and formation of star blooms or of witches' brooms result in the non-formation of pods; and the pods formed on healthy cushions are liable to direct infection by which they may be rendered useless Furthermore, the presence of the dead witches' broom twigs serves as a point of entry for the die-back fungus.

The causative fungus cannot spread backward into the healthy tissues of the tree, except in one particular kind of infection; while its actual progress from tree to tree is slow. It spreads by means of spores, produced on infected pods and on the basis of witches' broom branches, in small pustules of a dirty white or pink colour such as are characteristic of the genus Colletotrichum. It has been found that a moist atmosphere favours the growth of the fungus, but the nature of the soil is without influence on the occurrence of the disease.

Since the spread of infection is slow, it is probable that the malady could very easily be eradicated if it were treated on its first appearance. Remedial measures would involve the cutting out of all infected parts, or the cutting back of the tree as is described below, followed by the spraying of both the infected plant itself and of the trees in its neighbourhood with Bordeaux mixture. In Surinam, however, the disease assumed such proportions that most stringent measures were found necessary. The trees were cut back in the dry season, until only the three or four main branches were left. Then they were thoroughly sprayed with Bordeaux mixture, while the wounds were carefully protected. All the branches removed were burnt. It was found that the trees treated in this way gave a vigorous growth of healthy branches, in a short space of time.

Witches' brooms in the Cameroons were first recorded by Busse in 1905, and were subsequently investigated by von Faber as has already been stated. They arise from an infected bud, which, as it develops, produces an abnormal thick, fleshy branch with shortened internodes; usually a number of adventitous buds arise at the base of the main twig and the whole forms an erect, conspicious clump. The leaves on these twigs are only slightly developed, have a short blade, and dry up quickly. The witches' brooms have only a week vitality, though they may persist for several years. This persistence, in conjunction with the fact that they never produce flowers, serves to distinguish these witches' broome from those found in Surinam. Two other distinguishing features are, that in the Cameroons the disease does not attack the fruit, while it is apparently due to a different fungus.

The organism associated with the Cameroon disease is *Exoascus Bussei*, von Fab. Its mycelium permeates the tissues, and gives rise to asci beneath the cuticle of the leaf; these asci subsequently break through the cuticle and liberate their spores into the air. They are produced on either surface of the leaf, chiefly along the mid-rib, and form a greyish covering to the parts concerned.

The disease is of little importance, though its presence certainly reduces the yield of a tree. It is usually of sporadic occurrence except in very moist situations. It may be controlled by the removal and destruction of the infected portions of the tree.

PINK DISEASE. This was described by Stockdale[52], and occurs in the West Indies only in the islands of Dominica and St. Lucia as far as is known. A very similar disease due to an allied fungus occurs also on cacao in Java[56] and the Cameroons[18].

It appears as a pinkish incrustation of adpressed fungal hyphae, usually on the smaller woody branches of cacao. On the smaller branches it may completely cover the surface, while on larger ones it is usually confined to the damper side. The hyphae of the fungus penetrate the bark and occasionally enter the wood. The bark cracks, splits and peels off. Underneath, new bark is usually formed, and it is only rarely that an affected branch is killed. The chief danger from this disease lies in the opportunity of entry which the cracks due to it afford to wound parasites such as *Thyridaria tarda.*

The causative fungus has been identified at Kew as *Corticium lilacino-fuscum*, B. and C. Recently it has been found on the pigeon pea as well as on cacao, in St. Lucia. It occurs chiefly in damp shady situations and is most conspicuous during the rainy season. In this it resembles the allied species found on cacao in Java and the Cameroons, *Corticium Salmonicolor*, B. and Br. = *C. javanicum*, Zimm. = *C. Zimmermannii*, Sydow and Sacc. The latter is, however, a far more vigorous parasite and occurs on a large number of host plants of which the most important are Para rubber and coffee. It is found on various host plants other than cacao in Southern India,[1] Ceylon[45] and the Malay States[21], as well as in Java and the Cameroons. There is a possibility that the West Indian species is the same as that found in the East, though the local fungus is of far less economic importance and is apparently much more restricted in its range of host plants. It is hoped that steps may be taken to settle this point at an early date.

The disease is readily amenable to control, since the fungus may be destroyed by washing affected branches with lime-sulphur wash.

THREAD BLIGHTS. This is a disease that is very possibly due to more than one species of fungus, though the different forms are more or less similar in their general external appearance. It occurs in Trinidad, Grenada, St. Lucia, Dominica, Tobago and British Guiana. An account of it, as it is found in the West Indies, is given by Lewton-Brain[30].

The thread fungi consist of sterile strands of superficial mycelium that run over the branches and stems, closely adpressed to the bark. They generally run upwards on the young twigs and spread along the petioles to the leaf blades, on the under surfaces of which they ramify in a network of fine threads. Where two leaves touch, these filaments spread from one to the other, sometimes forming a thickened cushion at the point of contact. The colour of the threads varies somewhat with different

specimens, but is generally from light to dark brown or almost black in the older portions and white in the younger.

From the under surfaces of the strands, hyphae are given off which penetrate the crevices in the dead bark but do not appear to be able to pass through a fully formed corky layer to the living cells beneath On older branches, therefore, the fungus is a saprophyte, and the hyphae entering the bark crevices hold the threads in place. On young green twigs, however, they can penetrate and destroy the cortex and can spread to the medullary rays and even to the wood. They also destroy the buds and leaves, so that it is upon these portions that serious damage is inflicted.

It is interesting to note that thread blight has occasionally appeared on nutmeg trees in Grenada as well as on cacao, while forest trees in Trinidad would also appear to be occasionally infected; in the East, diseases of this nature are known on tea, coffee, nutmegs, camphor, Hevea, the mango, sapodilla and other trees, and on the Gold Coast [53] on cacao and kola, the latter being a forest host. The diseases have been attributed to different fungi; in the Windward and Leeward Islands, the causative fungi have never been known to produce fruit and are quite unidentified; in Trinidad [28] the different forms have been attributed to *Pellicularia Koleroga*, Cke. and *Coprinus* sp.; on tea they have been referred to *Stilbum nanum*, Massee, in India [54] and to *Corticium theae*, Bernard, [11] in Java; on Hevea and camphor in the Malay States [8] to *Corticium* sp. or *Hypochnus* sp. and on cacao and kola on the West Coast of Africa [53] [34] to *Marasmius scandens*, Massee.

The fungi spread by means of their mycelium only, in the West Indies; this is carried about by wind attached to small twigs or dead leaves. Their spread is encouraged by damp, shady conditions. The disease may be kept under control by severe pruning and by carefully burning all infected material. The application of lime-sulphur wash to the fungal threads would also probably prove useful.

HORSE HAIR BLIGHT. The appearance of this disease is fairly accurately described by its name, for it resembles a tuft of horse hair caught in the branches. It occurs in Trinidad, Grenada, and St. Lucia in the West Indies [30] [52], on tea, Hevea and nutmegs in Ceylon [36] [41] [42] and on tea and jungle trees in India [55], while it may be noted that it has also occurred in connexion with thread blight on nutmegs in Grenada. It is uncertain at present if the horse hair blight is really quite distinct from one of the forms of thread blight, since in addition to the black horse hair-like strands, closely adpressed strands also occur on the surface of the bark. The method of spread is the same as that of thread blights, while birds may assist in this case by carrying off the strands for building their nests. Specimens of this fungus sent from Trinidad to Kew were identified as *Marasmius equicrinis*, Müll. In India [55] the disease is attributed to *M. sarmentosus*, Berk; while in Ceylon [36] that on nutmegs is due to *M. rotalis*, B. and Br.

This disease is only occasionally and sporadically responsible for any serious damage. It may be kept under control in the same manner as are thread blights.

SEEDLING DISEASE. On two occasions cacao seedlings grown at Kew from seed received from the West Indies have been destroyed soon after germination by a fungus that first showed as a white mould on the cotyledons. This disease was described by Massee [33] and attributed by him to a fungus which he named *Ramularia necator*. A similar disease is reported on cacao seedlings from the West Coast of Africa [5]. A disease appeared on cacao seedlings in the nursery at the Botanic Gardens, St. Lucia, in January 1910, which was associated with the presence of a species of Fusarium. In April of the same year seedlings were received from another district in St. Lucia which showed the presence of spores resembling those of *Ramularia necator*, as well as pustules of a Fusarium. This disease has not been thoroughly worked out, but it may be the same as that described by Massee. Until its nature is more fully understood, no remedial measures can be recommended with certainty. Spraying with dilute Bordeaux mixture would possibly arrest its spread, but it may actually originate as a dormant mycelium within the cotyledonary tissue of a bean.

MISCELLANEOUS STEM DISEASES. Cacao trees in Trinidad are occasionally subject to the attacks of a wound parasite most commonly found on species of Ficus, such as the banyan trees in Trinidad and the Barbados evergreen in Barbados [15, 28]. Its host plants, which are various, also include the mango. The fungus was described by Massee [31] as *Eutypa erumpens*; it forms hard plates of dull black stromata beneath the bark, which eventually break through and become superficial. They are carbonaceous in substance, often of considerable extent, and contain the perithecia of the fungus sunk in them. On account of their size and colour they form conspicuous objects on attacked trees. The fungus spreads slowly but eventually causes the death of the tree. Its presence is hard to detect at first, as it has no early external manifestation. The disease is of rare occurrence on cacao, and has received but little attention.

A peculiar condition of trees known as 'male' cacao is to be met with occasionally in most of the cacao-producing islands, notably Trinidad, Grenada and Dominica. Large numbers of flowers, sometimes associated with vegetative branches, are produced from the cushions. The flowers are abnormal, and rarely give rise to pods. When they do so, the pods are usually small and abortive and fall off when still young. Only very rarely is a normal pod produced. In Trinidad, Rorer [48] and Fredholm [20] have found a species of Colletotrichum associated with this condition. In Dominica it is believed to be connected with canker, but there is no accurate knowledge available on this point. Howard[29] stated that trees attacked by *Calonectria flavida*, Massee, in Dominica, exhibit this peculiar development, but since this fungus is now considered to be a saprophyte, it can hardly be held responsible for the appearance, and, as it is mainly on account of the presence of this fungus on the trees that the 'flowering disease' or 'male' cacao was supposed to be connected with canker, this second point also is now doubtful. In some cases it would appear that the same tree exhibits this excessive flowering year after year; but there are no authentic records, so far as the writer is aware, to indicate if such trees show this con-

dition throughout their life-history, or only develop it subsequently, after commencing as trees bearing normally. If they showed the male condition throughout their lives they might possibly be peculiar sports, and the phenomenon would then be merely an abnormal variation not due to any specific organism, at least in some cases. Possibly also, all instances of male cacao are not due to the same cause. In any case, this subject requires further investigation.

Finally, the occurrence of a peculiar colouration of the bark may be recorded. This has been seen in Dominica and St. Vincent. The bark shows a red colour when cut, that is darker than the healthy normal pink of some varieties, but is different from the discoloration due to canker, and, moreover, is general throughout the bark on the older parts of the tree. In St. Vincent it was noticeable on trees badly attacked by thrips. Its cause is uncertain, as on one or two occasions portions of such bark that were carefully sterilized on the surface developed no organism of any kind, while in some instances *Spicaria colorans* developed; this may well have entered the tissues after they were cut and before they were disinfected. On the whole, the evidence tends to show that the colour is due to a generally unhealthy state of the tree and not to a specific organism. Such a hypothesis accounts most satisfactorily for its presence over a large part of the tree showing it. If this supposition is correct, the red colour can only be taken as an indication of general ill health, possibly often caused by want of cultivation and manuring, and not existing as a symptom of any specific organic disease.

ROOT DISEASES.

Information on this subject has been of a somewhat uncertain nature in the West Indies, owing to the fact that fructifications of the causative fungi have not been obtained, while it has not been clearly recognized that more than one form exist. Recent work, conducted by the writer, has shown that in all probability two diseases, in addition to that due to *Thyridaria tarda*, are of general occurrence. The investigations on this subject are now in progress and have not been concluded, so that the information given is not final or complete.

THYRIDARIA ROOT DISEASE. Under the name of *Macrophoma vestita*, Prillieux and Delacroix [40] in 1894 described a fungus found on the roots of cacao in Central America. The same organism under the title of *Lasiodiplodia* sp. was described by Stockdale [52], from specimens of a young cacao tree that had died of a root disease in Trinidad. The specimens were forwarded to the Head Office of this Department by Hart, and were identified at Washington. Finally, Griffon and Maublanc [22] recorded its presence on cacao roots in the French Congo, under the name *Lasiodiplodia theobromae*. All these names are now known to be synonymous with *Thyridaria tarda*, as has already been indicated. The fungus is probably capable of acting as a parasite on the roots of cacao in any locality where the soil is low-lying and ill-drained. Infected trees of three or four years of age die fairly rapidly. The bark of diseased roots is found to

be dry, and separates easily from the wood, which is of a grey colour. On the surface of the bark appear the black pustules containing the pycnidia of the Diplodia stage of this fungus. Further details of the parasite have already been given, and need not be repeated; while reference has also been made to the number of different host plants upon which the organism can live.

Remedial measures should consist of the removal and burning of dead trees with their roots, and the removal of infected roots of trees in their neighbourhood. This should be followed by attention to drainage and by careful cultivation; at the same time remedial measures against the attacks of this fungus on the pods and stems would probably reduce its prevalence on the roots.

WHITE ROOT DISEASE. This name is given to a form of disease described by Howard [20] from Grenada on cacao and nutmegs, and known locally as root canker. Auchinleck [3] states that it occurs on cacao, coffee, nutmegs, bread fruit and bananas; while Howard thinks that it is the same as that found by Barber [9] in Dominica in 1892-3 on cacao, mango, orange, coffee and bread fruit trees.

The description of root disease given by Stockdale [52] does not apply to this disease, but to the black root disease mentioned below, as has been shown by recent investigations in St. Lucia.

Auchinleck's [3] account of its symptoms in Grenada is as follows:—

'Some root-disease is caused by a definite organism, a fungus, which penetrates the roots and lives on the soft growing area lying between the bark and the wood. Its symptoms are the shedding of the leaves and the gradual dying-back of the tree from the tips. If the bark be removed from the tap-root or from a lateral root, the wood and the inside of the bark are seen to be covered with whitish threads grouped together in a very characteristic manner. Apparently in its younger stages the fungus forms star-shaped clusters growing from a common centre, the clusters being about an inch in diameter; later these clusters thicken and we have fan-shaped felts of hyphæ. The fungus is in all cases white.'

No fructifications of this form of disease have ever been found, as far as is known, but Howard [20] states that the mycelium contains clamp connexions usually considered characteristic of the Basidiomycetes. The writer has not made a comparison of this form in Grenada with the black root fungus, but hopes to do so at an early date. However, the descriptions given by Howard and Auchinleck, when compared with the appearance of the black fungus, would seem to leave but little doubt that the Grenada disease is distinct, unless very serious oversights have been made in describing it.

The fungus can travel underground in an ever-widening circle, so that its spread must be stopped by means of a trench in the usual manner. Dead trees and their roots should be dug up and burnt, and a heavy dressing of lime should be forked into infected soil. In early stages of the disease a cure may be effected, according to Auchinleck,[3] by forking in green vitriol (iron sul-

phate) among the diseased roots. It is noticeable that in Grenada the disease occurs most commonly on heavy wet lands, in the heights or on the banks of streams.

BLACK ROOT DISEASE. This has been found to attack cacao, limes, pois-doux and mahoe cochon (*Sterculia caribaea*) as well as Hibiscus and Acalypha in Dominica. Diseases with very similar symptoms, but occasioned in some instances by different species of the same genus, occur on cacao, Castilloa, limes, and the pigeon pea, and are found in St. Lucia, St. Vincent and Grenada; so alike are these different forms in their general appearance, that they may all be described under the same popular name. A fuller account of this disease appears in another paper that is presented at this Conference, so that it will only receive slight attention here.• In Dominica, it occurs sporadically on newly cleared estates, usually at a considerable elevation, and apparently spreads to living crops from dead or dying forest trees in most instances. Infected trees show a thinning of the foliage which is often not very noticeable, but is followed by a sudden wilting of all the leaves, while within two or three days of this the tree is found to be completely dead. An examination of the roots reveals the presence of dark-brown, somewhat fluffy strands of external mycelium. Round the stem, for a height of 6 inches to 2 feet, is a dark olive-green covering of mycelium that is grey along its advancing margin. The bark is dead and dry, and beneath it fan-shaped patches of a white mycelium may be found on the surface of the wood. A hard crust often forms in the bark, from which thin black lines ½-mm. wide, run back horizontally into the wood, which in old dead roots is dry and powdery. The fungus causing the disease is a species of Rosellinia, as is shown by the nature of its perithecia and conidia, as well as its mycelial characters. The reproductive organs are borne on the superficial mycelium round the base of the stem. The conidia are formed first, soon after the death of the tree. They are borne on erect bristle-like conidiophores which project in large numbers at right-angles to the surface of the mycelium. They are crowded closely together and produce an effect like the pile of a carpet. Later, when the tree has been dead some time, the perithecia arise among the old conidiophores. In the case of the species found in Dominica (*Rosellinia bunodes*. B. and Br.) they are black, spherical and gregarious, and are covered with short club-shaped protuberances. The black spores are extruded from them in a mucilaginous tendril.

All dying or dead trees should be dug out and burnt before the conidia have time to form, and the soil should be well forked and, if possible, dressed with lime. The infected roots of trees in the neighbourhood should be cut off. If several trees are dying the infected area should be trenched in the usual manner. In Dominica it is found that when isolated trees die, their removal and destruction are usually sufficient to prevent the spread of the disease. Further points likely to be of service in checking this disease may possibly suggest themselves when its investigation has been completed.

BROWN ROOT DISEASE. This occurs on cacao in Ceylon, Samoa, New Guinea and West Africa. In addition it is found on

Hevea, tea, dadaps (Erythrina), *Castilloa elastica*, Caravonica cotton, camphor, *Cinnamomum Cassia*, *Erythroxylum Coca* and *Brunfelsia americana*, in Ceylon [38]; on Hevea in the Malay States [47, 7], and in Southern India [2]; on coffee in Java; on Castilloa, bread-fruit and *Albizzia stipulata*, as well as jungle trees in Samoa [12]; and on Funtumia on the Gold Coast [41]. In spite of its wide-spread distribution, the writer has never seen it in the West Indies, and is unaware of any record of its occurrence there.

The presence of the disease is usually indicated by the death of the tree. 'When the tree is dug up the special characters of the brown root disease are immediately evident, and there can be no mistake in the diagnosis. The roots, especially the tap root, are encrusted by a mass of sand, earth and stones to a thickness of 3 or 4 mm., and, as a rule, the crust extends up the stem for several inches. This mass is cemented to the root by the mycelium of the fungus which consists of tawny brown threads, collected here and there into small sheets of nodules. In the early stages the predominating colour is brown, and the name given to the disease then appears more or less appropriate, but as it grows older the fungus forms a black continuous covering over the brown masses of hyphae, and the diseased root then appears chiefly black. In all stages, however, the encrusting mass of stones and earth intermingled with brown threads, serves to distinguish it.' (Petch.)[38]

The disease is due to a fungus called *Hymenochaete noxia*, Berk. Its fructification appears as a thin, dark-brown crust adhering to the base of the stem and in some countries completely covering the stem for a space of several inches. The fungus grows very slowly, and can only spread along roots in the soil; while it passes on to a healthy tree only when the roots of the latter are in contact with diseased roots. Thus it is not of a very serious nature. Like several other root fungi, it often commences its growth on decaying stumps and spreads from them to healthy trees.

As the fungus usually kills one tree before it attacks those in the neighbourhood, its spread is easily controlled by carefully removing the dead tree with all it roots, and cutting off the infected roots of any trees near it at a point where they are healthy.

This completes the list of cacao diseases to be described in this place. A few leaf fungi have been omitted, as well as one or two species found on the stems of these trees because they are not of much importance. The list is a somewhat formidable one, but it must be remembered that several of the diseases are of minor importance, while all are amenable to control measures. By far the most important parasite is *Phytophthora Faberi*. Even this causes but small damage, when it is considered that only occasionally has an attempt been made, with any degree of earnestness or from any immediate necessity, to bring it under adequate control; and that the employment of what is probably the most effective method of achieving this end, namely spraying with fungicides, is at present only in a very preliminary stage. Though this is

true of spraying, yet the value of other methods of sanitation is rapidly becoming recognized on cacao estates, with the result that in the West Indies there have been very few serious outbreaks of disease, even sporadically, in the last few years, while some forms, especially those due to *Thyridaria tarda* are becoming markedly less prevalent.

REFERENCES

1. Anstead, R. D. *Planters' Chronicle*, Vol. V, p. 210.
2. „ „ „ „ „ Vol. V, p. 546.
3. Auchinleck, G. G. *Proceedings of the Agricultural and Commercial Society*, Grenada, Nov. 18, 1910, Appendix 2, p. 159.
4. Bancroft, K. *West Indian Bulletin*, Vol. X, p. 34.
5. „ „ *A Handbook of Fungus Diseases of West Indian Plants*, p. 54.
6. „ „ Department of Agriculture for the Federated Malay States, Bulletin 9.
7. „ „ *Agricultural Bulletin of the Straits and Federated Malay States*, Vol. X, p. 106.
8. „ „ „ „ Vol. X, p. 110.
9. Barber, C. A. Supplement to the *Leeward Islands Gazette*, 1893, p. 52.
10. Barrett, O. W. *Proceedings of the Agricultural and Commercial Society of Trinidad and Tobago*, Vol. VII, p. 281.
11. Bernard, Ch. *Bulletin du Departement de l'Agriculture aux Indes Néerlandaises*, No. XXIII, p. 29.
12. Brick. *Jahresbericht der Vereinigung für angewandte Botanik*, Vol. VI, pp. 244-9.
13. Busse, W. *Der Tropenpflanzer*, 1905, No. 1.
14. Carruthers, J. B. *Circulars and Agricultural Journal* of the Royal Botanic Gardens, Ceylon, Vol. I, No. 23, p. 295.
15. Collens, A. E. *Bulletin of Agricultural Information*, Trinidad, 1909, No. 61, p. 33.
16. Delacroix, G. *Bulletin de la Société Mycologique de France*, Tome XXI, p. 191.
17. Von. Faber, F. C. *Der Tropenpflanzer*, Band XI, 1907, No. 11.
18. „ „ Arbeit aus der Kaiserlichen biologischen Anstalt für Land-und Forstwirtschaft 1909, Heft. 2, S. 225.
19. „ „ „ „ „ Heft. 3, p. 385.
20. Fredholm, A. *Proceedings of the Agricultural and Commercial Society*, Trinidad and Tobago, Vol. XI, p. 318.
21. Gallagher, Department of Agriculture, Federated Malay States, *Bulletin* 10.

22. Griffon and Maublanc. Bulletin de la Société Mycologique de France, Tome XXV, p. 51.

23. Guéguen, F. „ „ Tome XXVI, p. 287.

24. van Hall, A.E. and Drost, A. W. Departement van den Landbouw, Surinam, Bulletin 21.

25. van Hall, C. J. and Drost, A. W. The Witch Broom Disease of Cacao, English Translation by Dr. A. Fredholm. *Proceedings of the Agricultural and Commercial Society of Trinidad and Tobago*, Vol. IX, p. 475.

26. Hart, J. *Bulletin of Miscellaneous Information*, Botanical Department, Trinidad, Vol. III, pp. 167 and 182.

27. „ „ *West Indian Bulletin*, Vol. I, p. 422.

28. „ „ Cacao, Its Cultivation and Curing, pp. 99 and 101.

29. Howard, A. *West Indian Bulletin*, Vol. II, pp. 190-211.

30. Lewton-Brain, L. *West Indian Bulletin*, Vol. VI, p. 87.

31. Massee, G. *Bulletin of Miscellaneous Information*, Royal Botanic Gardens, Kew, 1898, p. 134.

32. „ „ „ „ 1899, p. 1.

33. „ „ „ „ 1907, pp. 243 and 298.

34. „ „ „ „ 1910, part 1.

35. „ „ *Proceedings of the Agricultural and Commercial Society of Trinidad and Tobago*, Vol. III, p. 317.

36. Petch, T. *Circulars and Agricultural Journal* of the Royal Botanic Gardens, Ceylon, Vol. III, p. 281.

37. „ „ „ „ Vol. IV, No. 23, p. 307.

38. „ „ „ „ Vol. V, No. 6, p. 47.

39. „ „ „ „ Vol. V, No. 13, p. 143.

40. „ „ „ „ „ „ „ „ pp. 147 and 149.

41. „ „ *Tropical Agriculturist*, Vol. XXIV, p. 25.

42. „ „ „ „ Vol. XXVI, p. 224.

43. „ „ *Annals of the Royal Botanic Gardens*, Peradeniya, Vol. IV, p. 445.

44. „ „ Physiology and Diseases of Hevea Brasiliensis, p. 189.

45. „ „ „ „ „ „ „ p. 208.

46. Prillieux and Delacroix. *Bulletin de la Société Mycologique de France*, Vol. X, p. 165.

47. Ridley, H. N. *Agricultural Bulletin of the Sraits and Federated Malay States*, Vol. VIII, No 7, p. 106.

48. Rorer, J. B., *Bulletin of the Department of Agriculture* Trinidad, Vol. IX, p. 34.

49. „ „ „ „ „ Vol. IX, p. 79.

50. „ „ Board of Agriculture, Trinidad, Annual Report of the Mycologist for the year ending April 30, 1910, p. 4.

51. „ „ Board of Agriculture, Trinidad, Circular No. 4, p. 7.

52. Stockdale, F. A. *West Indian Bulletin,* Vol. IX, pp. 166-87.

53. Tudhope, W. S. D. *Report of the Agricultural Department of the Gold Coast* for the year 1909, p. 9.

54. Watt and Mann. Pests and Blights of the Tea Plant, Second Edition, 1903, p. 392.

55. „ „ „ „ „ p. 410.

56. Zehnter, Proefstation voor Cacao te Salatiga, Bulletins 2 and 3, 1905.

57. Zimmermann, A. Centralblatt für Bakteriologie, Parasitenkunde und Infectionskrankheiten, Abt. II, Bd. 7, S. 143.

also Delacroix and Maublanc. *L'Agriculture Pratique des Pays Chauds,* 1909, part II, pp. 314, 393 and 472.

and Von Faber, F. C. Arbeiten aus der Kaiserlichen Biologischen Anstalt für Land-und Forstwirtschaft. Band VII, S. 193-351.

CACAO CANKER.

By E. Essed, B.Sc.

I spent six months on a cacao estate in Surinam in order to study thoroughly, canker, and I wish to put the results before the members of this Conference, so that they may be able to judge of them for themselves.

Allow me, however, to say beforehand, that Mrs. van Hall was right, when she assumed, that *Spicaria colorans* was the cause of the 'disease' although her inoculation experiments did not confirm the assumption; but her conclusion appeared to be the only possible inference that could be drawn from the pathological preparations and the pure cultures on cacao bark, on which the same discoloration was produced as was found within a cankered area, she therefore expressed the opinion *that the conditions under which infection could take place did not obtain during her inoculation experiments.* She was the first to question the nature of a gummy substance, which was always found, filling the cells and intercellular spaces; but, unfortunately, she could not account for it, and therefore suggested, that it might be of the same nature as those discovered by Professor Went in

witches' brooms and which he ranked with the undefined class of wound gums, but, it was cautiously added: 'Until their nature be better understood.' So we see that Professor Went himself had some misgivings, as to their being really wound gum. I am glad to say, that I am now able to give an explanation of the presence of these substances, the nature of which was so little understood, and so wrongly explained all the time. In fact, I have already given an explanation of these 'Pegmatia' as I termed them in my paper* on the Panama disease; but so little did I know at the time of their real relation to any described fungus or fungus-group that I considered them as belonging to a new fungus, on account of their most peculiar mode of forming a resting stage and chlamydospores, and assuming at the same time, in analogy to what happens in many other fungi, that the stilboid fruit body, bearing unicellular spores in heads, would in the end become the stroma, within which the perithecia would develop. I know now that this is not the case; I was wrong, but my error was the logical consequence of the failure of previous investigators to discover the true nature of these gummy bodies, which play such an important part in the life-history of these fungi. I had nothing to go by; I had to find it out myself.

A fuller description of these pegmatia than that which I gave in my paper on the Panama disease, minute details of their formation, development, germination, microchemical tests to detect their fungus origin, etc., will be given in a book that I hope to be able to publish, treating of the different diseases of cacao and sugar-cane in Surinam.

For the present I have to refer to the description in the paper on the Panama disease which gives a fairly good idea of the pegmatia. This much I may say now: the pegmatium is characteristic of the Nectrias, but probably of the Fusarium-producing, stromatic forms only.

To return to the point. In Surinam, I never met with a tropical case of canker. I only found red streaks in wood and bark, sometimes aggregated in such a way as to become more conspicuous, and the cambial region on one side of the branch often intensely discoloured. As I was always able to grow Spicaria from, and could find pegmatia in, the affected parts, I looked upon them as incipient or abortive cases of canker. These same cases are found here in Trinidad, as I was able to ascertain. Here also I saw for the first time a typical canker, the deep claret coloured bark with the dark line of demarcation from the healthy looking surrounding tissues and the viscous, reddish exudation on the bark.

Having got the opportunity to proceed with my investigation I wish here to tender my most cordial thanks to Mr. W. G. Freeman, Assistant Director of Agriculture, Trinidad, for all the kindness extended to me. I tried first of all to find out, where this viscous matter came from and what relation it bore to the disease. To be brief, I shall give an explanation, which is the result of most careful scrutiny of a large number of pathological preparations.

---

* See *Annals of Botany*, Vol. XXV, 1911.

The cankered area arises from pegmatia formed in the intercellular spaces and cells of the bark, and imparting to it the distinctive colour. In nearly all cases the cambium underlying the cankered area is destroyed, so giving rise to a space between wood and extra-cambial tissues, partly filled with pegmatium. The water brought from the vessels through the medullary rays is simply poured into the cavity, softening the pegmatium into a reddish, gelatinous mass. The softening goes on through the intercellular spaces, setting up a tension in the tissues, which results in cracking of the bark; through these or pre-existing cracks the transfusion of the reddish viscous matter takes places. If this be so, then the red efflux on the bark is pegmatium. One might compare it with the mycocecidia-like effluxes of pegmatium on the leaves of the banana, mentioned in the paper on Panama disease. And this again being so, we ought to be able to obtain a mycelium from it; this can actually be done. When a small fragment of dry substance is scratched off, a drop of 25 per cent. glycerine in water poured on to it, a cover-glass turned on it and pressed so as to produce a coarse powder (the substance is brittle) it will be seen after a fortnight or more that the pegmatium turns into a slimy mass with chlamydospores imbedded in it, or germinates at once, producing gemmæ in profusion. The newly-formed chlamydospores may be seen to germinate shortly after they are formed, producing short tubes on which numerous buds are developed in yeast-like fashion. (See the paper on Panama disease). Everyone will be able to convince himself of the truth of these statements so that I may refrain from further dilating on them. But what I wish to point out and lay stress upon is, that, when the discoloration of the cankered area is caused by the resting condition of a fungus formed in the cells and intercellular spaces absorbing the protoplasm, destroying the cambium and giving rise, when softened by the water pouring in through the medullary rays, to the exudation of the reddish, viscous matter on the bark, there can no room be left for the belief, that canker is caused by anything else but by the fungus to which this substance belong, i.e., a Nectria or its imperfect form *Spicaria colorans.*

However, the inoculation experiments of Mr. Rorer, or rather the interpretation of his results led him to the conclusion that canker was caused by Phytophthora. But in carefully reading his report, I find doubt prevailing as to whether Phytophthora is the real cause of canker. In the first place, serious objections could be raised against the mode of proceeding: inoculation experiments in the field, however isolated, cannot be considered to afford, from a purely scientific point of view, reliable and convincing data. For, where is the criterion for the absolute health of the tree in the field? Has Mr. Rorer tried to convince himself of the absence of any other germ in the bark, awaiting the predisposing moment Phytophthora, which will enable it to develop the symptom, which we call canker? If he had done so, he would have explained the presence of *Spicaria colorans* in 'cracks of bark about point of inoculation' in a way quite different from that contained in his report, in which he says: 'this shows how quickly the saprophytes follow.' This interpretation of the facts was wrong. It did not follow; it was in the bark

before the introduction of the Phytophthora, which was the predisposing moment for the development of a fungus, exhibiting a remarkable kind of parasitism. More of this later. I shall now give an account of my inoculation experiments, which were only carried out, so to speak, 'pour acquit de conscience.'

Seedlings were raised from selected seeds taken from pods which were thoroughly examined under the miscroscrope; sections were made of the peduncle, the husk and the placental stalk; only these pods were made use of, in the peduncle, husk and placental stalk of which no mycelium and pegmatium were found. I may here say, that out of seventeen ripe, apparently healthy pods only two could be found to satisfy the conditions. Twelve small clay pots were filled with sterilized soil and the seeds laid out, two in each pot. The pots were kept in a case, the under-part of which consisted of a concrete trough, 6 inches deep, the upper part of a wooden frame with glass panels, or sliding door giving access to the interior—a contrivance such as is used for mosquito-breeding. The trough was filled with water so as just to touch the laths which were laid across to support the pots, and with the aim of keeping the air comparatively moist, so that too frequent watering could be avoided. The water used was taken from a masonwork rain water reservoir and was always heated to boiling point and cooled down again before use. When the seedlings were fifteen weeks old and of a height of 1 foot and more one in each plot, where both seeds germinated, one was cut off and sections were made and examined under the microscope. All were found to be sound. This was only a means of arriving at the greatest possible certainty as regards the perfect condition of the material.

Four seedlings were inoculated with pure cultures of *Phytophthora*, four with *Spicaria colorans* and four were left to serve as controls. Scratches were made so as to expose the whitish tissue of the bark; bits of the pure cultures were lifted with a spatulate platinum wire, brought on to a moist bit of sterilized cotton wool, which was then placed on the wound, carefully wrapped around the stem and kept in its place with the aid of sewing yarn, tied around the upper and lower margins. Finally bits of tin foil were wrapped around the wool, with the edges closely pressed against the stem to prevent the wool from drying too quickly.

A week after the inoculation, one of the plants inoculated with Phytophthora showed signs of disease: the younger leaves at the top were wilting and on one of these blotches appeared on the lower part. I removed the cotton wool and found the bark darkened around the inoculated spot. Two days after, it was evident that the plant was dying: it had the aspect of chupon wilt as I later on saw it here in Trinidad. It was then cut off and examined. The bark was discoloured from about 2 cm. below the inoculation spot to the top of the little plant. The discoloured part had a very irregular, fringed outline; the colour in the middle was brownish and along the margins like the skin of a cooked potato, a shade between grey and yellow. No trace of a cork cambium could be detected, and although in sections the hyphae could be seen to run between the cells, the walls of the younger cells here and there collapsed, the protoplasm more or less contracted and became discoloured; no trace of the gummy substance and

reddish discoloration, so typical of canker, could be discovered. The remainder, after having been brushed and rinsed under the tap, then in distilled water and subsequently brought in a sterilized Petri dish, developed within two days the peculiar downy mycelium and long, tender conidiophores of Phytophthora, raised ½-inch above the medium, which was turning darker. A few days after, the conidia were shed and the material was perfectly black and rotten. The bandages of the other seedlings, inoculated with Phytophthora, were removed on the tenth day; they did not show any other external sign of disease but the darkening of the bark around the inoculation spot. In examining them more closely they were found to exhibit the same changes as were cited for the first, but the area affected was considerably smaller, and there was no reason to think that they would die. The bandages of the seedlings, inoculated with Spicaria, were taken off on the fourteenth day; there was no sign of disease, no change of the bark visible on the surface, and matters remained so until the end of a month, when one was cut off, of which sections were made. Then, it was found that the inoculation had taken effect; the hyphæ were preparing themselves a way through the inter-cellular spaces, and a single pegmatium had formed here and there. From the remaining portion pure cultures of Spicaria could again be raised. The controls were all perfectly healthy.

But why was no canker development obtained in either case? Why should Mr. Rorer obtain results different from mine? Was it due to the difference between his mode of operation and mine? To be sure, he operated with full-grown trees and I did so with seedlings; his trees were standing in the open field and my seedlings were raised and kept under rigorously sterile conditions. This expression is perhaps not quite correct, since the fire-cautions mentioned above, would not exclude bacteria; but, as bacteria are entirely out of the question and the examination of each second seedling in a pot proved them to be healthy, there was sufficient reason to assume that no undesirable *fungal germs* had entered the plants up to the moment of inoculation. Mr. Rorer mentions that the saprophyte Spicaria quickly followed the Phytophthora, but I found the Spicaria entering and living bacteria in the tissues of the cacao bark, although not causing any apparent damage at first. So the only possible inference to be drawn from all these data was that Spicaria was either a symboint or parasite which could only cause canker when the tissues were brought into a condition, deviating from the *absolute normal*, and this condition was probably afforded by Phytophthora. There is the proof of the latter. The remaining seedlings, inoculated with Spicaria, were reinoculated with Phytophthora and in less than a week the reddish discoloration was found to develop, and the affected area was in one case marked off from the healthy parts by a thin but distinct brown line: it was the aspect of developing canker so beautifully figured by Mr. Rorer; the sections showed pegmatia formed all over in the cells of the affected bark and wood and in the cultures from the material, prepared *lege artis*, both Phytophthora and Spicaria appeared.

Here we arrived at conclusions which will bridge the

difference between Mrs. van Hall and Mr. Rorer. They are as follows:—

Canker is caused by *Spicaria colorans*, or rather the Nectria to which Spicaria belongs, but only when its development is facilitated by a predisposing moment, which may be: (1) excessive moisture as Mrs. van Hall assumed—and this appears to have been the predisposing moment in Surinam; (2) Phytophthora, as was shown by Mr. Rorer's experiments; (3) any other factor, which is the cause of a reduction of the vitality of the plant.

The parasitism of the Nectrias has now to be considered. The Nectrias—perhaps I ought to say the pegmatium-producing Nectrias—display all gradations between extreme saprophytism and extreme parasitism. We all know how well they thrive on dead matter, demonstrating their extreme saprophytic character; but it is less known, that they may grow in living tissue without doing any harm at first: a kind of symbiosis, which is the transition of saprophytism to parasitism. But gradually the greedy messmate may adopt rapacious habits, so slightly interfering with the nutrition of its fellow symbiont; it becomes an isotrophyte. It may go on little further, more and more encroaching upon its friend, which is made a victim, and here the increased influence on the assimilation of the host may lead either to the suppression of growth or to the stimulation of abnormal growth: it turns into an atrophyte or a hypertrophyte. In the end it may exhibit kteinophytic habits, killing the entire host-plant.

The results of my inoculation experiments go far to show that *Spicaria colorans*, which is simply a conidium stage of a Nectria, could grow in the tissues, without causing any real damage; that is, it could be a symbiont. The cases of incipient or abortive canker, mentioned before, demonstrate the stage in which it slightly interferes with the assimilation of the cacao tree, being then an isotrophyte; the canker stage shows that it could be an atrophyte and hypertrophyte at the same time, the cankered area being the atrophied part and the wound cork, surrounding the cankered area, being due to hypertrophy. Finally, the tree dying after being ringed by canker, presents us with the picture of the kteinophytic habit of the Nectria. More instances of this pleomorphic parasitism may be cited, such as the 'little leaf disease' of the cocoa-nut tree, which is simply the atrophic condition of the disease of which the root rot of the same plant is the kteinophytic condition. It is to be concluded that the cocoa-nut diseases in this island are caused by a Nectria; the discoloration of the tissues is due to the formation of pegmatia in them, and the death of the tree to these pegmatia seriously interfering with the assimilation and water transport in the plant; the latter condition causes the withering of the leaves from the tips downwards and their falling back against the stem. Indeed, it is the very image of the Panama disease, and it is not unlikely that the disease is caused by the same Nectria. Mr. Stockdale found a Fusarium in his cultures, and this was to be expected; the Fusarium belongs to the Nectria, it certainly arose from the pegmatia, probably preceded by Cephalosporium. Mr. Rorer thinks the disease may be due to bad soil conditions;

this also may be right, because the Nectria would not attack the cocoa-nut tree, if its vitality was unimpaired. So beware of the Nectrias.

A POSSIBLE INFERENCE TO BE DRAWN FROM THE STUDIES ON CACAO CANKER.

BY DR. A. FREDHOLM.

Canker of the cacao tree is recognized as one of the most serious problems confronting the cacao planter. It has received considerable attention from phytopathologists. Some of our best workers in this line have at one time or another been engaged in its study, with the result that a large amount of literature on the subject is now available.

The studies on cacao canker are remarkable for the diversity of opinion at which the various writers have arrived as to the cause of this disease. It is not the purpose of this paper either to review or criticise the labours of those investigators, but rather to endeavour to harmonize them. On one point they all agree, namely the vagueness of the term 'canker'. In their descriptions of the symptoms and lesions they concur sufficiently to make it apparent that the conditions described are identical. It is only in the extent of the lesions that they differ, some investigators holding that the disease is confined to the tissues of trunks and branches, while others assert that it also affects the fruits. Although each writer makes special mention of some certain fungus belonging to some order comprising well-known parasites, or at least facultative parasites, as connected with the disease, they are loth to assert that the fungus they name is the specific cause and the only possible cause of the disease. They take pains always to record the presence of other fungi, which they generally regard as saprophytes following the pathogenic organism. As a rule, these supposed saprophytes are also members of orders, or sometimes of genera, which include well-known parasites, and the very fungus, which one investigator has been led to regard as a specific cause, is by his confreres held to be a harmless saprophyte. or vice versa. Mr. J. B. Rorer's paper Pod Rot, Canker and Chupon Wilt of Cacao Caused by Phytophthora sp., published in Vol. IX, No. 65 of the *Bulletin of the Department of Agriculture*, Trinidad, July 1910, forms a notable exception. In it the author states, without reservation, that a species of Phytophthora is the cause and only cause of the disease which he had been investigating, which he appropriately calls Phytophthora Pod Rot, and which he demonstrates can produce such lesions of the bark as are associated with the disease generally known as canker. Other careful workers have, however, felt justified in pronouncing other fungi the causes of canker, and in regarding Phytophthora as essentially a pod parasite. Such seems to be the status of our knowledge at present relative to cacao canker. From a practical point of view this state of affairs may be regarded as highly unsatisfactory; it leaves the planter in doubt —he knows not what particular organism he should endeavour to exterminate.

The cankered tissues of the trunks and branches exhibit few characteristics. Apart from several different mycelia which have been recorded as found in them, all lesions described appear to be similar. In advanced cases exudations take place which have been attributed to the activities of bacteria.

Canker may be defined as the gradual and continuous destruction of living tissue caused by the presence in it of a parasitic organism. It would be more in accordance with the evidence deducible from the writings of the various investigators to regard canker merely as *a condition arising from the action of a parasite* on the tissues of the host and *not as a specific disease.* Nearly all tissue-destroying parasites would produce like conditions. Many of the writers on cacao canker have commented on the indefiniteness of the term Canker, and they may hold somewhat similar views to those here expressed.

If we regard canker as a condition and not as a specific disease, then the disparity of opinions among the workers on the subject can be readily comprehended. Several parasitic fungi attacking the tissues of cacao trees may produce cankerous conditions. Information of great practical importance will probably result when phytopathologists have advanced further in their studies of the organisms found associated with cankered tissues, and have conducted careful inoculation experiments with pure cultures. Some such experiments have been done, when the aim has been to single out an organism suspected of causing the trouble, but they have not been conducted on a sufficiently large scale nor under varying conditions. It is conceivable that under certain conditions inoculations with one fungus may give positive results while the others give negative, but that under reversed or altered conditions entirely different results may follow.

Such deviations from opinions held are not anomalous in pathology; several analogies can be cited. The matter has more than once claimed the attention of the medical profession. Dr. Rumsey long ago pointed out: 'in many cases the certified causes of death are nothing more than modes of death, as cardiac syncope.' In the Registrar General's Classification of Causes of Death will be found a section designated Ill-defined and Not Specified Causes, which comprises: dropsy, debility atrophy, inanition, mortification, tumour, abscess and haemorrhage. Relative to this Section, the Revision Committee (1885) of the Royal College of Physicians said in its Report that it: 'felt it right to indicate as strongly as possible the necessity of avoiding the use of the names of symptoms wherever the names of diseases or of causes of symptoms could with reasonable certainty be substituted.' For this reason a diagnosis of peritonitis, standing alone, is vague and highly unsatisfactory, as it merely states that a certain morbid condition exists, without giving the cause for this condition.

If it should be proved that different parasitic fungi can give rise to diseases involving cankerous conditions, then the comparative study of these conditions would soon lead to the discovery of symptomatic differences by which in each case the cause of the condition could easily be determined, and we may soon be familiar

with, and have fully described under specific names, several distinct diseases exhibiting cankerous conditions, which are now included under the one name Cacao Canker. Mr. Rorer has taken the first step in this direction when he names the disease on which he has worked Phytophthora Pod Rot and shows that the rot of the pod can extend into the tissues of the branch and trunk and there give rise to cankerous conditions. It is to be hoped that other investigators will follow, and that their labours will soon clear up the obscure points in the etiology of Cacao Canker.

INSECT PESTS OF CACAO.

BY P. L. GUPPY, F.E.S.,

Assistant Entomologist, Board of Agriculture, Trinidad.

The Cacao Beetle.

INTRODUCTION. The following notes are mainly taken from Circular No. 1* of the Board of Agriculture, and it is very satisfactory to have to record increased activity in the campaign against the cacao beetle (*Steirastoma depressum*, L.) since it was issued.

More attention has been paid to the systematic trapping and collecting of beetles, with the remarkable results shown further on.

Birds and lizards are the planter's best friends, and it is principally because of their presence in certain localities that immunity from the attacks of beetles is enjoyed.

The writer is much indebted to Messrs. W. C. Jardine, of Caura, Mr. H. Hutton, of Caroni, and Henry C. Warner, of Carapichaima for valuable information and records.

FOOD PLANTS. The favourite food plant is chataigne maron or wild chataigne (*Pachira aquatica*). Other food plants are silk cotton (*Eriodendron anfractuosum*), immortel (*Erythrina umbrosa*, and allied species), ochroe or okra (*Hibiscus esculentus*), forest mahoe (*Sterculia caribaea*), cannon ball tree (*Couroupita guianensis*), gemauve (*Malachra capitata*), hog plum (*Spondias lutea*) and matapale (*Clusia rosea*).

All the above are occasionally attacked, but the main attraction is the cut wood of the wild chataigne, which has resulted in *its successful use for trapping the cacao beetles in large numbers.*

NATURE OF DAMAGE DONE. It is somewhat difficult to estimate the actual damage done in old established cacao, but from the number of dead branches and occasional dead trees seen, and the miserable-looking trees here and there in beetle infested areas, it is safe to say that thousands of dollars are annually lost in large properties, where no proper and systematic control measures are adopted.

**The Life-History and Control of the Cacao Beetle*, issued May 9, 1911.

In young contracts, where trees range from two to six years old, not only are many lost, but large numbers are attacked in a certain degree, not sufficiently to kill them, but to retard seriously their growth and reduce crop returns, and also to add to heavy loss ultimately.

Trees of all ages suffer as mentioned above, and the damage is done by the 'worms'; but another form of damage must not be overlooked, and that is the constant 'scarring' or 'scarifying' of the tender bark of chupons and young branches by the *adults* with their powerful jaws, when feeding. This must often produce a sort of die-back, especially during dry seasons.

There is nothing so unsightly as a beetle-infested property, both as regards the badly shaped, dying stems and branches, and the hacked up bark where worms have been cut out, which go to produce an array of disfigured, untidy-looking trees.

PREDACEOUS ENEMIES, BIRDS AND LIZARDS. It would seem that *all* birds are useful to the cacao planter, especially those of the woodpecker type, even though some of the latter do occasionally make holes in pods. The good they do far outbalances the loss from the few dozen pods attacked.

The King of the Woods, or Boo-too-too (*Momotus Swainsonii*), has been accused of eating young pods, and I am sorry to say many have been shot in consequence; but the bird has been proved to be insectivorous, at any rate to a large extent, and there is a reliable record that it is an enemy of the cacao beetle. In reference to this beautiful bird, which is very well known in Tobago, it is interesting to quote the following from The Birds of Tobago, by G. F., published in the *Trinidad Mirror* of October 6, 1811: 'The food consists of insects and berries, the bird being especially fond of the seeds of Castilloa. It is *supposed to damage cacao pods*, but the harm done is very small, certainly not enough to warrant the destruction of such a beautiful creature.' In two specimens of this bird suspected to have eaten cacao pods, and dissected in the writer's presence, only insects and seeds were found.

The protection of lizards is quite as important. All lizards are very useful, especially those that climb along the branches of trees. Like snakes, lizards are often killed in a thoughtless manner, but whereas there are a few venomous snakes, there is no such thing as a harmful lizard.

Recently, an examination was made of the contents of two lizards' stomachs. They were taken in a beetle-infested area, and both were found to contain cacao beetles.

Among insect enemies there are two ichneumons and the larvae of certain Elaters The question in regard to their value as natural controls is now being investigated.

METHODS OF TRAPPING BEETLES.

KINDS OF TRAPS USED. The following traps, composed of

branches and bark of the Chataigne tree, viz:—

No. 1 Suspended traps.
„ 2 Fork „ } Composed of bark and branches
„ 3 Leaning „ }

have proved most practical and effective.

For No. 1, various sized branches, cut up into 2-foot lengths, and from 1 to 3 inches thick, suspended from 2 to 5 feet from the ground near main stem of cacao tree.

Give bark of trap-wood a few gashes on two opposite sides, and then after a day or two, on the other two sides. This causes exudation of sap which attracts the beetles; this will add to the effectiveness of the traps.

No. 2. Fork traps: use any odd pieces of wood (*as long as there is bark on one side*), placed at the 'jorquet' or fork of the tree. Pieces of thick bark are very effective, used in this way.

No. 3. Leaning traps are composed of fairly long pieces of bark, or branches placed between forks, one end resting on the ground and the other end leaning against trunks of trees near the collar.

HOW TO USE TRAPS WITH BEST EFFECT. At Caroni, Mr. Hutton has used Nos. 1 and 2 traps, mostly, combined with the following methods, which have resulted in large captures.

Choose spots at intervals, and at equal distances throughout the estate, and on these spots do some cutting away that will let in more light than there is in the rest of the field. To effect this, a little pruning of the cacao trees should be done, say about 100 trees in each selected area; or if there are trees growing with the cacao that are not required for shade purposes, have them branched and felled. In this way a small clearing will be made, and both owing to pruning and broken cacao branches caused by felling trees, there will be a great attraction for the beetles on account of the exudation of sap from cut and wounded limbs.

It will be found that beetles will flock to such spots for weeks after clearing has been done, and if the traps recommended are systematically used the beetles will concentrate on, and lay in, the chataigne wood, so that they can be easily captured and their eggs destroyed.

SOME USEFUL HINTS. Trap-wood, when too dry, ceases to attract beetles. Renew weekly in dry weather.

Under chataigne trees from which the traps have been cut there will be an abundance of small branches, etc., which will attract a large number of beetles, and careful search should be made for them. A clear space should be made, and all the small ends dumped on it so that when the miscellaneous pieces are scattered during the search for beetles it will be easy to see what is being done. The beetles are not readily seen on the ground, it will therefore be necessary to be particular about having the dumping spot quite clear of grass, bush, or rubbish,

The chataigne tree itself, from which the trap-wood is cut. will be made a large attraction for the beetles, by gashing the bark from the collar, just above the roots, to a height of about

5 feet. The attraction can be made still greater, if the tree is ring-barked at about the same height, with the additional advantage that large numbers of eggs will be laid in the *bark below the portion ring-barked*, and the same bark can be afterwards stripped off and used again as 'fork' and 'leaning' traps.

The great advantage of these strips of bark is that they dry up so thoroughly in a few days that the eggs and young larvae perish; and the trouble of removal and burning is done away with, and the rotten wood affords a mulch for the trees.

THE BEST TIME TO SEARCH FOR BEETLES. From 9 a.m. to 4 p.m. on sunny days is the best time to search for beetles On wet days few are seen. I have often observed the beetles feeding at night, but I do not think there is any advantage to be gained by searching for them at that time. They are not attracted by lights.

I strongly recommend the employment of only the most intelligent and keen-sighted men or boys for this work; it is perhaps best to keep one good man, or boy, solely for the purpose of catching beetles, cutting out 'worms' and dressing wounds.

THE DESTRUCTION OF TRAP-WOOD: I have often been asked whether it is necessary to burn trap-wood after use. To be on the safe side this should be done; that is to say, wherever portions of fairly thick branches are used this *must* be done, but where strips of bark, or very small branches have been used they dry up sufficiently quickly and thoroughly to cause the destruction of eggs and young larvae. If, however, the latter can find enough nourishment to get past a certain stage they will develop into perfect insects even in dry wood, and this will surely happen in such pieces as are used for suspended traps. There will be no necessity for removing the small twigs and chupons left on the ground after a light trimming; they dry up and rot sufficiently rapidly to prevent the danger of providing a breeding ground for beetles.

PRECAUTIONS TO BE TAKEN IN THE USE OF CHATAIGNE TRAPS. From the time that a chataigne tree is wounded, it becomes not only an attraction for the beetles to feed on but for egg-laying purposes as well. Whenever the trees are ring-barked with the object of drying them, daily inspection of such trees is absolutely necessary, as beetles will be found, and egg-pits will be numerous, on that portion *below the circular cutting*, right down to the roots. Very few beetles will be found above the ring-barked portion.

After about two months, the bark must be stripped off in lengths; these lengths of bark can be set out as traps in the usual way, and they will prove very effective, but of course will dry up rapidly; this will however obviate the necessity for burning.

It is very important that chataigne trees growing near, or on, cacao estates should be kept under close observation.

Whenever a branch is broken from some cause or other, it should be removed by cutting away completely to the stem of the tree, and the portions cut away burned, or used as trap-wood.

The wounds left on the trees must be dressed with tar or arsenate of lead; the latter dressing is strongly recommended for all wounds on shade and cacao trees in beetle-infested areas.*

Chataigne trees to be planted for use as trap-wood must be placed in a spot away from cacao cultivation, and at the same time they should be so situated that they will be under daily observation.

They will grow best in moist situations near ponds or streams. Twenty or twenty-five trees are quite sufficient, when full-grown, to supply all trap-wood necessary.

Since Circular No. 1 of the Board was issued, the writer has found that cacao is being grown under chataigne shade more than ever was suspected by him. The practice should certainly not be continued, and where possible this dangerous shade tree should be removed, or only a certain number reserved for trap-wood purposes.

METHOD OF COLLECTING BEETLES. The usual way of collecting beetles is by hand from traps, trees, etc. Jarring them off into a butterfly net was recommended, but since trying a funnel apparatus with bag made of coarse netting, I think there is much less risk of losing any beetles when there are many to be removed in a hurry. When jarred off into the funnel with bag they cannot escape and may be killed subsequently, by the usual process of pulling off their heads, or by any other process the planter may wish to adopt.

RECORDS OF CACAO BEETLES CAUGHT. Systematic trapping was only commenced about the latter part of last year (1911), on a large scale.

TABLE A.

Locality.	Date. From	Date. To	No. of months.	No. of beetles.
Caroni	August 23, 1911	Decr. 15 1911.	3 months 22 days.	11,000
Oropuche-Sangre Grande	,,	,,	,,	5,000
Caura	June 17, 1911.	,, 16	6 months.	18,416
			Total :	29,416

* One pound of arsenate of lead to 5 gallons of water. The mixture must always be agitated before using, and should be painted on wounds with a brush.

The weather, last year, was favourable for the pest, the biggest catches being made from the end of September to the middle of October.

At Caroni the highest average was between the 18th and 24th September, when in six days 2,117 beetles were captured—an average of nearly 353 per day!

In Caura, between October 8 and 14, the highest was 928 in six days.

Mr. Jardine writes, under date December 23, 1911: 'Visible signs of attacks are greatly reduced.'

THE COST OF COLLECTING AND LABOUR USED. Mr. Hutton, Caroni, says that if trapping is thoroughly and systematically carried out in the season when beetles are numerous, the cost should not be more than 40c. per 100, and may go as low as 15c.

Mr. Jardine, at Caura, caught 13,416 beetles at a cost of \$62·01, which works out at about 46c. a hundred.

As I mentioned before, I strongly recommend the employment of the most intelligent and keen-sighted men or boys for this work. At Caroni, Mr. Hutton employed one man, who captured 7,441 beetles in thirty-two days—an average of 232 per day.

SUMMARY.

It is absolutely necessary for all planters to join in the crusade against the pest.

There is no difficulty about catching and destroying the beetles, as will be seen by a persual of the accounts of the foregoing methods recommended, which have been tested and found effective.

Remember that chataigne planted for trap-wood should be placed in situations where the trees can be under constant observation; not that the beetles will attack strong trees, but immediately there is a wound, the beetles will be attracted, and trees may get wounded in many ways, so that it is best to have them under constant observation.

The writer has noticed that cultural methods have a great deal to do with the effects of beetles on cacao trees. No doubt, highly cultivated trees are readily attacked; but their resistant powers being greater, they soon recover from beetle attacks, wherever systematic trapping and removal of worms are combined with proper cultural methods.

It is very important that great care should be exercised when undesirable shade trees are to be removed, or when shade is to be reduced. The cutting out of timber attracts beetles, *which unless trapped*, may multiply exceedingly both in broken cacao branches and felled timber on the ground, *especially if the latter be chataigne*. The list of food plants given in this paper should be consulted, and wherever such trees are cut the trunks and branches must be destroyed, or some measures adopted to prevent the beetles from breeding in them.

APPENDIX.

In regard to the greater attraction which ring-barked chataigne trees have for beetles, I asked Mr. Jardine, who has had a lot of experience in trapping beetles by various methods, to what did he attribute this particularly strong and practically irresistible attraction. His reply is as follows :—

'I believe the explanation is to be found in the sequence followed by the process of decay in a ring-barked tree. This may be briefly described thus :—

'When a tree is ring-barked, the downward flow of the elaborated sap—which travels in the cortex (or bark)—to feed the roots is arrested, and the food-supply of the roots effectually cut off. The result of this is that the part of the tree *below* the ring is slowly starved to death, the cortex loses its vitality and its tissues become relaxed; which condition is well known to be particularly favourable to the larval stage of the beetle.

'That portion of the tree *above* the ring retains its vitality much longer, because the upward or mineral sap, which flows io the wood, continues its functions as long as the roots are able ts absorb, and the elaborated sap stream continues downwards an far as the ring. For this reason the cortex of the tree *below* the ring will be found dead and decaying while the tree above the wound is alive and green.

'The tree endeavours to re-establish communication with its roots by running a callus down the injured part to join up with the cortex below the wound. Should this succeed, the tree will be saved, and failing that it tries to save itself by throwing out shoots below the ring to form a new head.

'When the roots die, and the ascent of the mineral sap ceases, the tree *above* the ring begins to die also, and beetles will be found to attack it as freely as they did the lower portion.

'It appears evident that severed and decaying portions of their food plants are the favourite media for the larvae of the beetle from the large number that will always be found in such whenever the beetle is prevalent. This predilection for rotting tissues is markedly evident in the procedure of the twig girdlers* and so many other beetles.

'(Sgd.) W. C. JARDINE,

'Wardour Estate,

'Caura.

'February 3, 1912.'

---

* *Ecthoea quadricornis* and *Oncideres tesselatum*.

THE CACAO THRIPS.

An extensive and severe exidemic of Thrips (*Heliothrips rubrocinctus*) at Sangre Grande was reported early in December 1911 and seems to be still spreading. (This statement was made on January 20, 1912.)

FORMER RECORDS OF ATTACKS. In 1906, at Sangre Grande, and in 1909 in the Guaico District, attacks were severe but confined to certain localities; the present epidemic at Sangre Grande is the most extensive on record, in Trinidad, as far as can be remembered.

NATURE OF DAMAGE DONE. From evidence that I have been able to gather, it seems that the pest has existed in Sangre Grande for many years, and that excessive changes of leaf to which in former years no specific cause could be attributed must have undoubtedly been due to thrips: there were seven changes of leaf during this year No doubt, to a certain extent, climatic conditions have a good deal to do with fall of leaf, but then those conditions also regulate the severity of the attacks of thrips. As is well known, loss of leaf means drying of young pods and loss of a large percentage of the crop. In regard to this pest, as well as others, cultural methods will of course have a great deal to do with the resistant power of the cacao trees.

CONDITIONS FAVOURABLE TO INCREASE. Dry weather and no shade seem most favourable. There is no saying to what extent this pest might increase during very dry seasons wherever it happened to become established.

Adult thrips can fly, and are readily scattered by high winds.

CONTROL MEASURES. The Board of Agriculture's Circular of February 24, 1911, by Mr. Urich, deals with this pest, and kerosene emulsion is recommended for spraying trees. Syraying operations are being carried out on the recommendations made in this Circular, the following formula being used :—

Kerosene	2 gallons
Water	1 gallon.
Hard soap	½-lb.

This stock solution must be prepared in the usual way 1 gallon is diluted in 15 gallons of water.

The Besnard type of knapsack sprayer is being used, as well as other types. In spite of every care in the preparation of the kerosene emulsion, there is no doubt that, in the type of machine mentioned, the oil is apt to separate after a short time and rise to the top of the water, as there is no agitator. It is absolutely necessary to have a machine which keeps the contents constantly agitated. There are types which meet these requirements and they should be used if spraying is to be effective. The cost of two applications of spray would be about 2c. a tree, assuming that about a gallon of mixture is used for each tree, which would be quite sufficient.

SUMMARY.

It seems that fields attacked by thrips recover and bear as good crops as formerly; there is no doubt, however, that excessive loss of leaf reduces the vitality of the trees, and this damage occurs in such an insidious manner that it is not readily observed and may account for reduced yield in cacao trees in the course of time.

It would be well for planters to keep a careful lookout for the pests that have been notified as harmful, and to take prompt measures.

It is said that thrips attack the immortel. I have not been able to verify this, and it is hoped that this is not the case. They are fond of cashew, mango and almond (*Terminalia Catappa*) —in fact these trees harbour thrips all the year round, and I do not recommend their being grown near cacao, unless they are thoroughly sprayed two or three times a year.

Leaf-Eating Beetles.*

These small beetles (*Neobrotica* spp, *Colaspis* spp. *et al*) have again become very troublesome; as soon as young cacao leaves are put forth they are reduced to a 'ragged', untidy condition by the beetles feeding on them. A list of the beetles appears at the end of the paper.

In Sangre Grande District this has caused a severe strain on trees; after loss of leaf caused by thrips, the fresh crop of tender leaves is attacked by these pests. Spraying with arsenate of lead is recommended.

Podhoppers.

In certain localities podhoppers (*Horiola arcuata* and allied species) are sufficiently numerous to cause a certain amount of damage; but this happens only where ants, principally those of the genus Azteca, are abundant. These build their cartoon nests over the podhoppers, and prevent the hymenopterous parasites from getting at the eggs.

To control the pest, the ants must first be destroyed. Recommendations are given in Circular No. 3, Board of Agriculture, Trinidad, pp. 5, 6 and 15.

Additional Observations.

There are, of course, a great many other pests in Trinidad, but so far the above mentioned may be reckoned as the most important.

Fortunately the planter has a great many insect friends which act as natural controlling agents.

In certain instances the upsetting of the balance of Nature such as the killing of birds, and the introduction of the mongoose, and to a great degree the clearing of forest lands, has been the cause of trouble to planters.

---

* See Circular No. 3 of the Board of Agriculture, Trinidad, issued August 9, 1911.

The following table (Table B) gives only an imperfect list of cacao insects, but nevertheless indicates the vast amount of work to be done in the cacao fields. The knowledge of most of these is very superficial, and it is highly important that the life-histories of all should be worked out as some of them may at any time come into prominence as important pests.

TABLE B.

PRELIMINARY LIST OF INSECTS AFFECTING THE CACAO TREE, ARRANGED MORE OR LESS IN ORDER OF IMPORTANCE.

Scientific name.	Popular name.	Remarks.
1. *Steirastoma depressum*	Cacao beetle	Circular No. 1.*
2. *Heliothrips rubrocinctus*	Thrips	Circular of February 24, 1911.
3. *Horiola arcuata* and variety	Podhopper	Circular 3, pp. 5-6
4. *Neobrotica* sp.	Leaf-eating beetle	Circular 3, pp. 3-4
5. *Neobrotica* sp.	,,	,, ,,
6. *Colaspis* sp.	,,	,, ,,
7. *Diabrotica* sp.	,,	,, ,,
8. *Rutela lineola*	,,	,, ,,
9. *Brachyomus tuberculatus*	,,	,, ,,
10. *Ancistrosoma farinosum*	,, 'Chafer'	,, ,,
11. *Lachnosterna patens*	,, 'Large Chafer'	,, ,,
12. *Otiorhynchus* spp.	,, 'Weevil'	,, ,,
13. *Pelidnota* sp.	,,	,, ,,
14. *Aphetea inconspicua*, Fowl.	Podhopper (Green)	
15. *Endoiastus caviceps*, Fowl.	,,	
16. *Trachyderes succinctus*	Longicorn beetle	Circular No. 3
17. *Ecthoea quadricornis*, Oliver	,, ,, (Twig girdler or Cacao pruner)	,,
18. *Endesmus grisescens*, Savt.	Longicorn beetle (Girdler)	
19. *Xyleborus perforans*	Shot borer	*Proc. Agric. Soc. Trin. and Tobago*, April 1911. Paper No. 459.
20. *Platypus* sp.	,,	,,
21. *Dactylopius citri*	Mealy-bug	Cacao pods mostly.
22. *Aspidiotus lataniae*	Nipple scale	,,
23. *Aspidiotus destructor*	Nipple scale	*West India Committee Circular*, Nov. 23, 1909.

TABLE B.—(*Concluded.*)

Scientific name.	Popular name.	Remarks
		West India Committee Circular, Nov. 23, 1909
24. *Lecanium* sp.	Brown scale	,,
25. *Aphis* sp.	Black aphis	,,
26. *Aleyrodes* sp.	White fly	,,
27. *Embia urichii*	Spiderweb insect	,, *
28. *Embia trinitatis*	,,	,,
29. *Azteca* spp.†	Balata ants	Circulars 3 and 5, *Proc. Agric. Soc. Trin. and Tobago*, April 1911.
30. *Atta cephalotes*‡	Parasol ants	
31. *Atta octospinosa*		

* The Circulars quoted refer to publications of the Board of Agriculture, Trinidad.

† Various species of ants play an important part in the spread of Coccids, Aphids, Membracids and such like sucking insects found in cacao.

‡ Of course parasol ants are well-known and important pests of cacao, but these have been controlled effectively for some years past by the use of carbon bisulphide.

N.B. There are numerous lepidopterous insects (butterflies and moths) that attack the foliage mostly, but only in exceptional instances have they given even slight trouble.

MANURIAL EXPERIMENTS ON CACAO IN TRINIDAD.

BY J. DE VERTEUIL, F.C.S.,

Assistant Analyst, Department of Agriculture, Trinidad.

Manurial experinents on cacao are being carried out by :—

(1) The Department of Agriculture.

(2) The Board of Agriculture.

EXPERIMENTS UNDER THE DEPARTMENT OF AGRICULTURE.

RIVER ESTATE.

The Department of Agriculture experiments are being made at River Estate, Brooklyn Estate, and on four estates in Tobago. River Estate is the property of the Trinidad Government. It is situated in the Diego Martin Valley in the Ward of St. Anns and is about 9 miles from Port-of-Spain. The average annual rainfall for the past three years is 75 inches. The primary object in purchasing the estate was to control the water sources of the district for increasing the water-supply of Port-of-Spain. The estate comprises about 1,400 acres of which 225 acres, planted in

cacao, are being worked as an ordinary cacao estate; another 300 acres of flat land are being planted by contractors. The remaining portion consists of a ridge of hills forming a semicircle around the flat, and contains many valuable timber trees.

A. Field No. 1. In October 1909, plots of approximately fifty trees each were marked out in Field No. 1, for experimenting with various manures in different proportions, three plots being kept as a control.

This field is situated in the Diego Martin Valley; the soil, which is well drained, may be described as a sandy loam. The cacao trees are fairly regular in size, and about eleven years old. They are planted 12 feet by 12 feet and are at present shaded with immortel trees about 48 feet apart, the intervening trees having been gradually cut out.

The manures were spread broadcast to within 3 feet of the trunk of the trees and the soil forked up to a depth of about 6 inches. Where a mulch was applied the soil was previously forked. The mulch consisted of grass and bush obtained from the estate roads and adjoining uncultivated lands.

When pen manure was applied together with artificial manures, the former was first forked into the soil and the artificial manures spread over it. The pen manure was obtained from the village and cost slightly more than \$1·44 (6s.) a ton, carted to within 200 yards of the plots.

The control plots were also forked up, but no manures added.

The bird manure No. 1 applied to plots H, I and J contained more phosphates but less potash than No. 2, which was applied to plots K and V. I analysed these manures and also a sample of the sheep manure, with the following results:—

	Bird manure. No. 1, per cent.	Bird manure. No. 2, per cent.	Sheep manure. per cent.
Water	18·35	12·74	47·71
Organic and volatile matter* ...	11·48	13·82	32·76
Mineral matter†	70·17	73·44	19·53
*Containing:—			
Total nitrogen	0·54	0·32	1·34
†Containing:—			
Potassium oxide	1·78	2·36	1·45
Phosphoric anhydride	19·55	14·86	0·70
Equal to tribasic phosphate of lime	42·68	32·40	0·98

Throughout this report the value of the manures, other than pen manure, is calculated on the cost landed in Port-of-Spain. The cost of manuring includes the value of the manures, carrying to the plots and forking, and in the case of mulch, cost of cutting and carrying to the plots.

The record of pods picked from the different plots is being kept from September 1 to August 31, in each year. August and September are the months during which the smallest amount of cacao is reaped, and by recording the results as above a more uniform return for each period of twelve months should be obtained.

During the course of the twelve months from September 1910 to August 1911, it was noticed that the yields from certain plots were very poor, and it was deemed advisable to try to ascertain whether there are any local conditions peculiar to these plots to account for the fact.

Accordingly, the girth of each tree was measured 3 feet above the ground, and the soils from the central plots analysed. Other facts noticed are given in the course of the report.

The average girth of the trees for each plot is given in Table I, and it will be observed that the plots giving the poorest yields are those whose trees have the smallest girths; the trees, although practically of the same age, are of poorer growth.

The treatment to which each plot has been subjected, the cost of manuring and records of the number of pods picked from each plot, and the average per tree, are given below:—

TABLE I.

EXPERIMENT PLOTS.—FIELD NO. 1.

Mark on plots.	No. of bearing trees.	Average girth of trees, 3 feet above the ground (inches).	Manures applied, per plot.	Date when applied.	Cost of manuring, per plot.	Number of pods picked, per plot.	Average number of pods picked, per tree.
					$ c.		
A	49	13·3	Control		25*	895	18·3
B	51	14·4	280 lb. sheep manure 100 „ bone meal 25 „ sulphate of potash	2.11.1909	3 70	989	19·4
C	49	15·6	280 „ sheep manure 13 „ sulphate of ammonia 13 „ sulphate of potash	3.11.1909	2 18	1,031	21·0
D	52	15·7	560 „ sheep manure	3.11.1909	2 40	1,383	26·6
E	50	16·2	7,200 „ pen manure	22.11.1909	7 97	1,900	38·0
F	49	16·2	3,600 „ pen manure 100 „ basic slag 13 „ sulphate of potash	24.11.1909	5 32	1,664	33·9
G	50	16·1	Control		25*	1,490	29·8
H	48	16·5	187 lb. bird manure No. 1	4.11.1909	2 25	1,542	32·1
I	48	17·2	94 lb. bird manure No. 1 25 „ sulphate of ammonia 50 „ sulphate of potash	11.11.1909	3 53	1,840	38·4
J	50	15·5	94 lb. bird manure No. 1 13 „ sulphate of ammonia 25 „ sulphate of potash	11.11.1909	2 46	1,545	30·9
K	51	15·8	94 lb. bird manure No. 2 100 „ basic slag 25 „ sulphate of potash	11.11.1909	2 80	1,420	27·8
L	49	14·8	187 lb. lime	2.11.1909	97	689	14·1

* Cost of forking.

TABLE I.—(*Concluded.*)

Mark on plots.	No. of bearing trees.	Average girth of trees, 3 feet above the ground (inches).	Manures applied, per plot.	Date when applied.	Cost of manuring, per plot.	Number of pods picked per plot.	Average number of pods picked, per tree.
					$ c.		
M	50	15·2	5,000 ℔. mulch 100 „ basic slag 25 „ sulphate of potash 5,000 „ mulch	2.11.1909 10.1.1910	5.04	1,468	29·4
N	49	14·7	50 ℔ basic slag 5,000 „ mulch 5,000 „ mulch 13 „ sulphate of ammonia 13 „ sulphate of potash	26.11.1909 30.11.1909 11.1.1910 7.3.1910	5 77	956	19·5
O	51	14·8	10,000 ℔. mulch 10,000 „ mulch	4.1.1910 13.1.1910	6 36	1,125	22·0
P	52	15·2	3,600 ℔. pen manure 100 „ bone meal 13 „ sulphate of ammonia 13 „ sulphate of potash	25.11.1909	6 81	1,810	34·8
Q	49	16·0	3,600 ℔ pen manure 13 „ sulphate of ammonia 25 „ sulphate of potash	26.11.1909	4 91	2,129	43·4
R	51	16·5	25 ℔. sulphate of ammonia 25 „ sulphate of potash	4.11.1909	1 74	2,017	39·5
S	49	15·4	200 ℔. bone meal 25 „ sulphate of ammonia 25 „ sulphate of potash	4.11.1909	4 96	1,283	26·2
T	52	16·3	100 ℔. basic slag 25 „ sulphate of ammonia 25 „ sulphate of potash	26.11.1909 7.3.1910	2 66	1,501	28·9
U	51	16·2	Control		25*	1,636	32·1
V	52	16·5	187 ℔. bird manure No. 2.	4.11.1909	1 93	2,020	38·8
W	51	16·8	94 ℔. lime	2.11.1909	61	1,997	39·1

Average of control plots G and U. ... ... 30·9

* Cost of forking.

By comparing the yields per tree given in the table it above, will be observed that the plots A, B, C, D, M, N and O are poorer than plots E and P which bound with them. (See ground plan Table II.)

Plot L is situated in close proximity to bamboo clumps, and the roots from these have affected the trees to such an extent as to render the plot useless. Plot K has undoubtedly suffered from the same cause, but to a less extent. The bamboo clumps have been cut out, and it is hoped that these plots will improve.

Plot S has also given a poor yield per tree. The average girth of the trees is 1 inch less than that of the plants in plots R, H, and T which are situated next to it. Nothing has been noticed which might account for these facts

TABLE II.

SHOWING ARRANGEMENT OF MANURIAL EXPERIMENT PLOTS IN FIELD NO. 1.

No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 13·3 18·3	**A**			
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	50 15·2 29·4	**M**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	51 14·4 19·4	**B**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 14·7 19·5	**N**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 15·6 21·0	**C**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	51 14·8 22·0	**O**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	52 15·7 26·6	**D**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	52 15·2 34·8	**P**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	50 16·2 38·0	**E**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 16·0 43·4	**Q**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 16·2 33·9	**F**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	51 16·5 39·5	**R**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	50 16·1 29·8	**G**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 15·4 26·2	**S**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	48 16·5 32·1	**H**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	52 16·3 28·9	**T**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	48 17·2 38·4	**I**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	51 16·2 32·1	**U**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	50 15·5 30·9	**J**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	52 16·5 38·8	**V**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	51 15·8 27·8	**K**
No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	51 16·8 39·1	**W**	No. of bearing trees Average girth of trees (inches) No. of pods picked, per tree	49 14·8 14·1	**L**

The soil from each control plot A, G and U was analysed to ascertain whether there is any difference in their composition. Table III gives the results of analysis of the fine soil and natural soil, for each plot respectively. dried at 100° C. By Natural Soil is meant the soil containing the pebbles and sand, as found in the field. By Fine Soil is meant that portion of the soil which has passed through a sieve having forty holes to the inch, after having being air-dried and rubbed in a mortar.

TABLE III.

COMPOSITION OF SOIL DRIED AT 100°C.—FIELD NO. 1.

	Plot A.		Plot G.		Plot U.	
	Fine soil.	Natural soil	Fine soil.	Natural soil	Fine soil.	Natural soil
Pebbles and sand ...	—	18·600	—	9.700	—	10·300
Volatile matter and combined water* ...	4·430	3·606	4·911	4·435	4·435	3·978
Soluble silica	0·225	0·183	0·368	0·332	0·204	0·183
Oxides of iron and alumina	4·835	3·936	7·929	7·160	7·470	6·700
Lime	0·069	0·056	0·103	0·093	0·086	0·077
Magnesia	0·051	0·041	0·055	0·050	0·051	0·046
Potassium oxide ...	0·213	0·173	0·294	0·265	0·219	0·196
Sodium oxide	0·053	0·043	0·092	0·083	0·103	0·092
Phosphoric anhydride..	0·121	0·098	0·103	0·093	0·114	0·102
Sulphuric anhydride ...	0·067	0·054	0·077	0·069	0·105	0 094
Chlorine	0·002	0·002	0·003	0·003	0·003	0·003
Insoluble silica and silicate	89·934	73·208	86·065	77·717	87·210	78 229
*Containing :— Total nitrogen ...	0·158	0·129	0·154	0·139	0·143	0·128

PERCENTAGE OF AVAILABLE PLANT FOOD.

Potassium oxide ...	0·0055	0·0045	0·0065	0 0059	0·0077	0·0069
Phosphoric anhydride	0·0128	0·0104	0·0065	0·0059	0·0092	0·0082
Nitrogen as nitrates ...	0·0024	0·0019	0·0044	0·0040	0.0035	0·0031

The above figures show that the soils from the three plots are deficient in lime; and that plot A is of a more sandy character and contains less available potash and nitrogen than G and U, which are fairly similar in composition. The soil of plot A may be considered as slightly inferior.

In considering the results obtained from these experiments it would be advisable to consider A as the control plot for B, C, D, M, N, and O, as this portion of the field is inferior. The average of G and U could be taken as control for the other plots.

It would be well to point out that the returns given in the column Average number of pods per tree (Table I) do not indicate the best results from a financial point of view, as the cost of manuring must be deducted from the value of the produce reaped so as to arrive at the actual benefit derived fram manuring.

The net value of the cacao obtained per acre has been calculated and is recorded in Table IV, for future reference. In calculating these returns, twelve pods have been taken to make a pound of dry cacao. The trees being planted at 12 feet apart, 300 trees are calculated to the acre, and the value of dry cacao has been fixed at 11c. per ℔.

Table IV.

MANURIAL EXPERIMENTS.

Mark on plots.	Number of pods, per acre.	Dry cacao, per acre.	Value of dry cacao, per acre.	Cost of manuring, per acre.	Net value of cacao, per acre.
		lb.	$ c.	$ c.	$ c.
A	5,479	456	50 16	1 53*	48 63
B	5,818	485	53 35	21 76	31 59
C	6,812	526	57 86	13 35	44 51
D	7,979	665	73 15	13 85	59 30
E	11,400	950	104 50	47 82	56 68
F	10,188	849	93 39	32 57	60 82
G	8,940	745	81 95	1 50*	80 45
H	9,633	803	88 33	14 06	74 27
I	11,500	958	105 38	22 06	83 32
J	9,270	772	84 92	14 76	70 16
K	8,353	696	76 56	16 47	60 09
L	4,218	351	38 61	5 94	32 67
M	8,808	734	80 74	30 24	50 50
N	5,853	488	53 68	35 33	18 35
O	6,618	551	60 61	37 41	23 20
P	10,442	870	95 70	39 29	56 41
Q	13,035	1,086	119 46	30 06	89 40
R	11,865	997	109 67	10 23	99 44
S	7,855	655	72 05	30 37	41 68
T	8,660	722	79 42	15 35	64 07
U	9,623	802	88 22	1 47*	86 75
V	11,654	971	106 81	11 13	95 68
W	11,747	979	107 69	3 59	104 10
Average of conurol plots G. & U.			85 14	1 48*	83 66

* Cost of forking.

From the above table it will be seen that the returns from only four plots, namely, W, R, V and Q compare favourably with the average returns from control plots G and U, and that although the returns from plot A are comparatively small, six plots give poorer returns than control plot A, although the average girth of the trees in plot A is smaller.

Three plots, E, F and P, have given a good yield per tree, but owing to the high cost of manuring the pecuniary results are unfavourable.

Reliable comparisons, however, cannot be made on the results obtained from one year's experiments, for their value must rest on the gratuitous and probably false assumption that the yield from the manured plots was the same as that from the control plots previous to the application of the manures.

The net value of the cacao per acre may appear very large to the experienced cacao planter, even after deducting the cost of cultivation, but it must not be forgotten that these calculations are based on an acre containing 300 bearing trees—a condition which rarely, if ever, exists throughout any large plantation.

B. Field No. 6. Owing to the poor yield obtained from Field No. 6, namely 5½ bags per 1,000 full-bearing trees, during the financial year ending March 31, 1910, it was decided to carry out a few manurial experiments there, on a larger scale.

This field is situated on the side of a fairly steep hill facing north, and the plots were marked out from top to bottom so that any manure which might be washed down by the rains would not run on to another plot. The manures were applied broadcast on the surface, but no forking was done, except to plot 7 (pen manure).

The soil is a red loam of 3 to 4 feet depth, resting on a gravel subsoil. The cacao trees are about twenty-five to thirty years old, and planted 14 feet by 14 feet. All the foreign trees, such as the mango, hog plum (*Spondias lutea*, L.), bread nut or chataigne (*Pachira aquatica*, Aubl.) were cut out, and when too large they were barked so as to avoid causing too much damage to the surrounding cacao trees. These so-called foreign trees are absolutely injurious to any cacao plantation. The immortel trees which remain as shade are few and are at irregular distances.

The bird manure applied to these plots was the one described above as No. 2, and the sheep manure was of the same quality as that applied to Field No. 1.

The soil from the control plot has been analysed and the results recorded in the following table:—

TABLE V.

COMPOSITION OF SOIL DRIED AT 100° C. – FIELD NO. 6.

	Fine soil, per cent.	Natural soil, per cent.
Pebbles and sand	—	21·000
Volatile matter and combined water* ...	9·035	7·138
Soluble silica	0·707	0·558
Oxides of iron and alumina	19·485	15·393
Lime	0·151	0·119
Magnesia	0·095	0·075
Potassium oxide	0·147	0·116
Sodium oxide	0·067	0·053
Phosphoric anhydride	0·104	0·082
Sulphuric anhydride	0·094	0·074
Chlorine	0·003	0·002
Insoluble silica and silicates	70·112	55·390
*Containing :—		
Total nitrogen	0·215	0·170

PERCENTAGE OF AVAILABLE PLANT FOOD.

Potassium oxide	·0079	·0062
Phosphoric anhydride	·0067	·0053
Nitrogen as nitrates	·0032	·0025

Although the soil contains a larger proportion of pebbles and sand than the control plots in Field No. I, the analytical results show that it contains practically as much available plant food as the control plot G ; but it should be mentioned that the physical condition is inferior. The poor yield previously obtained from Field No. 6 is no doubt due, in great measure to this fact.

The relative position of the plots is shown in the next table:—

TABLE VI.

SHOWING ARRANGEMENT OF MANURIAL EXPERIMENT PLOTS IN FIELD NO. 6.

1	2	3	4	5	6	7	8	9
4 tons sheep manure.	1 ton bird manure No. 2.	1 ton sheep manure. 1 ton bird manure No. 2.	18 tons mulch.	27 tons mulch. 150 lb. sulphate of ammonia. 150 lb. sulphate of potash. 1.200 lb. bone meal.	27 tons mulch. 1,200 lb. basic slag. 300 lb. sulphate of potash.	70 tons pen manure.	2,000 lb. basic slag. 125 lb. sulphate of ammonia. 250 lb. sulphate of potash.	Control.

In Table VII is recorded the manurial treatment for each plot, the cost of manuring, and the number of pods picked, per plot and per tree, for the twelve months September 1910 to August 1911.

Table VII.

MANURIAL EXPERIMENT PLOTS.—FIELD NO. 6.

Mark on plots.	Number of bearing trees.	Manures applied, per plot.	Date when applied.	Cost of manuring, per plot.	Number of pods picked, per plot.	Average number of pods picked, per tree.
				$ c.		
1	1,018	4 tons sheep manure	Feb. 1910	36 60	17,083	16·8
2	500	1 ton bird manure No. 2	19. 3. 1910	21 20	15,567	31·1
3	520	1 ton sheep manure ... ... 1 „ bird manure No. 2	19. 3. 1910	30 40	14,994	28·8
4	202	18 tons mulch ...	Feb. 1910	22 60	6,081	30·1
5	307	27 tons mulch 150 lb. sulphate of ammonia 150 lb. sulphate of potash ... 1,200 lb. bone meal	Feb. 1910 30. 5. 1910 8. 8. 1910	60 43	11,773	38·3
6	300	27 tons mulch 300 lb. sulphate of potash ... 1,200 lb. basic slag	Feb. 1910 1. 7. 1910	53 48	12,420	41·4
7	1,000	70 tons pen manure	March 1910	167 35	41,284	41·3
8	504	2,000 lb. basic slag 125 „ sulphate of ammonia 250 lb. sulphate of potash ...	30. 5. 1910 10. 8. 1910	29 79	10,049	19·9
9	500	Control			4,881	9·8

With the exception of the pen manure plot, these plots were not forked.

It may be pointed out that, although plots 6 and 7 have

given slightly better yields per tree than R, V and W in Field No. 1 (see Tables I and VII), owing to the greater distance at which the trees were planted in Field No. 6, the yield per acre is much less in the latter (see Tables IV and VIII).

In calculating the yield obtained per acre, from Field No. 6, it has been assumed that there are 220 trees to the acre, as the trees there are planted 14 feet apart.

TABLE VIII.

MANURIAL EXPERIMENTS.—FIELD NO. 6.

Mark on plots.	Number of pods, per acre.	Dry cacao per acre.	Value of dry cacao, per acre, at 11 c. per lb.	Cost of manuring, per acre.	Net value of cacao, per acre.
		lb.	$ c.	$ c.	$ c.
1	3,692	308	33 88	7 91	25 97
2	6,849	571	62 81	9 33	53 48
3	6,344	529	58 19	12 86	45 33
4	6,623	552	60 72	24 61	36 11
5	8,437	703	77 33	43 30	34 03
6	9,108	759	83 49	39 22	44 27
7	9,082	757	83 27	36 82	46 45
8	4,386	365	40 15	13 00	27 15
9	2,148	179	19 69	...	19 69

Taking the field as a whole, the results obtained from manuring have been very favourable. Last year's yield for the field was 5·64 bags per 1,000 trees as compared with 11·55 bags per 1,000 trees this year, and it will be noted that the yield from the control plot is nearly 5 bags per 1,000 trees.

From the above table, it will be seen that the best paying plot, this year, is No. 2; for although 5, 6 and 7 have given a larger yield to the acre, the cost of manuring these plots was much higher than that of plot 2.

I wish to call special attention to the fact that it would be very unwise to draw hasty conclusions from one year's results.

C. Field No. 9. In June 1911, three plots of approximately 320 bearing trees each were marked out in Field No. 9 for experimenting with Ohlendorff's cacao manure. The soil is a flat sandy loam.

The cacao trees are about nine years old, planted 12 feet apart and regularly shaded with immortel trees.

Three pounds of Ohlendorff's cacao manure was applied to each tree in plot 1, and 2 ℔. to each tree in plot 3, on July 7, 1911. Plot 2 is kept as a control. The number of pods picked from each plot is being recorded from September 1, 1911.

D. Shade and Chupon Experiments. Experiments are also being made with regard to shade and chupons or suckers, as is shown in Tables IX and X.

In Table IX will be found the results of pickings obtained from the shade experiments from October 1910 to August 1911 for A, B and C. Plots I and J were started later, and the records cover a period of nine months from December 1910 to August 1911.

In calculating the yields per acre for trees planted 15 feet apart, it has been reckoned that there are 190 trees to the acre.

TABLE IX.

SHADE EXPERIMENTS.

Mark on plots.	Number of bearing trees.	Age of trees, years.	Distance planted, feet.	Treatment.	Number of pods picked, per plot.	Number of pods picked, per acre.
A	500	25 to 30	15 × 15	Full shade	23,960	9,105
B	500	„	„	No shade	30,461	11,575
C	500	„	„	Partial shade	26,787	10,179
I	1,863	7 „ 8	12 × 12	No shade	16,859	2,715
J	1,905	9 „ 10	„	Full shade	37,539	5,912

It is important to note that the soil on which these experiments are being made is a sandy loam.

No shade trees were removed from A ; there are 116 immortel trees planted in this plot.

In B, every bocare immortel was cut out, and all the anauco trees barked in July and August 1910.

About 50 per cent. of the immortel trees in plot C were barked in August 1910, and sixty trees were left to provide shade.

In plot I all the immortel trees were completely cut out in October and November 1910. Banana suckers were planted in the open patches in January 1911, so as to protect the land from the direct action of the sun.

The immortel shade trees in J are fairly regularly planted, at 24 feet apart.

It will be seen in Table IX that the partial shade plot C has given an increase of 1,074 pods, and the no-shade plot B 2,470 pods more per acre than the full-shade plot A.

The yields obtained from I and J are recorded for future reference.

The results of pickings obtained from the Chupon plots during the ten months November 1910 to 1911, are given in Table X.

TABLE X.

CHUPON EXPERIMENTS.

Mark on plots.	Number of bearing trees.	Age of trees, years.	Distance planted, feet.	Treatment.	Number of pods picked, per plot.	Number of pods picked, per acre.
D	100	7 to 9	12 × 12	All chupons allowed to grow	2,964	8,892
E	100	,,	,,	3 ,, ,, ,,	2,504	7,512
F	100	,,	,,	2 ,, ,, ,,	2,675	8,025
G	100	,,	,,	1 chupon ,, ,,	3,687	11,061
H	100	,,	,,	No chupons ,, ,,	3,487	10,461
DD	100	25 to 30	15 × 15	All chupons allowed to grow	5,736	10,898
EE	100	,,	,,	3 ,, ,, ,,	4,663	8,860
FF	100	,,	,,	2 ,, ,, ,,	4,169	7,921
GG	100	,,	,,	1 chupon ,, ,,	4,363	8,290
HH	100	,,	,,	No chupons ,, ,,	5,886	10,613

The object of these experiments is to see in what way the yield will be affected by allowing all the chupons or some, or none, to grow up from the base of the tree.

The above results are recorded for future reference. It is not advisable to draw conclusions from these experiments until results have been obtained covering a period of several years.

BROOKLYN ESTATE.

Manurial experiments are being made on the Brooklyn Estate at Sangre Grande, about 30 miles east of Port-of-Spain. The field under experiment is 11 to 12 acres in extent and was originally divided into two plots, but later plot 1 was subdivided into two, 1 a and 1 b.

The soil is a deep loam, situated practically at the junction of the Sangre Grande and Cunapo rivers. A chemical analysis has been made, the results of which are given below.

The cacao trees, which are eighteen to twenty years old, are planted at a distance of 13 by 13 feet and regularly shaded with immortel trees.

The following manures are being experimented with: pen manure, sheep manure, basic slag, bone meal, bone superphosphate, sulphate of potash and sulphate of ammonia.

The manures are supplied free of cost by the Department, at the Sangre Grande Railway Station, but all other expenses are to be borne by the proprietor, who has the benefit of the cacao reaped from the plots.

The manures were spread broadcast between the trees about three feet from the trunk, and the soil lightly forked up. There are four control plots which are lightly forked up but no manures added. Records of pickings are being kept from September 1, 1911.

A sample of soil from the experiment plot at Brooklyn Estate was found to contain, per cent:—

Water	3·68
Volatile matter and combined water	7·46
Mineral matter	88·86

The percentage composition of the sample, dried at 100° C., was:—

Volatile matter and combined water * ...	7·750
Soluble silica	0·384
Oxide of iron and alumina	10·787
Lime	0·057
Magnesia	0·192
Potassium oxide	0·287
Sodium oxide	0·155
Phosphoric anhydride	0·096
Sulphuric anhydride	0·124
Chlorine	0·002
Insoluble silica and silicates	80·148
* Containing:—	
Total nitrogen	0·158
The available plant food present was per cent.:—	
Potassium oxide	·0080
Phosphoric anhydride	·0080
Nitrogen as nitrates	·0016

TOBAGO ESTATES.

CACAO AND CASTILLOA RUBBER EXPERIMENTS. The manurial experiments in Tobago are being carried out on a mixed cultivation of cacao and Castilloa rubber trees on four estates. Two of these, Caledonia and Cocoawattie, are situated about the centre of the island; the other two, Richmond and Louis d'Or, are on the windward side.

The directions given to the proprietors for applying the manures were the same as those described under the heading River Estate, for Field No. 1. The manures were applied between April and June 1911. Records of pickings from the cacao trees are being kept from September 1, 1911. The girths of the rubber trees are to be measured in April of each year, and the yield of dry rubber obtained from each plot recorded.

Caledonia Estate. (Cacao.) The plots are situated on hilly land of a loamy charatcer. They consist of 2 acres planted in cacao with immortel shade and divided into four plots of about ½-acre each. The trees are fifteen to sixteen years old, and planted at irregular distances. The manures used are basic slag, bone meal, sulphate of potash and sulphate of ammonia.

Caledonia Estate. (Mixed cacao and rubber.) There are four plots of about ¼-acre each, cultivated with cacao and Castilloa rubber trees. Both the cacao and rubber are about ten years old. The cacao is planted at a distance of 14 feet by 12 feet, and the rubber 28 feet by 24 feet. Basic slag, bone superphosphate, sulphate of potash, sulphate of ammonia and mulch are being used in the experiments.

Cocoawattie Estate. (Mixed cacao and rubber.) There are four plots of ¼-acre each, planted with cacao 10 feet apart and Castilloa rubber trees 20 feet by 20 feet. One plot is kept as a control. The cacao and rubber trees are four years old. The following manures are being used: basic slag, bone meal, bone superphosphate, pen manure, sheep manure, mulch, sulphate of ammonia and sulphate of potash.

Richmond Estate. (Mixed cacao and rubber.) About 1½ acres are divided into five plots, one being kept as a control. The cacao trees are planted at a distance of 18 feet by 12 feet, and the Castilloa rubber trees about 24 feet apart. The cacao trees are twelve years old and the rubber trees about eleven years of age. The soil is a heavy clay, and the manures used for the experiments are as follows: mulch, pen manure, sheep manure, sulphate of ammonia, basic slag, bone meal and sulphate of potash.

Louis d'Or Estate. (Mixed cacao and rubber.) One acre of land has been divided into four plots of ¼-acre each, one plot being kept as a control. The cacao trees are eight years old and planted at 12 feet by 17 feet; the Castilloa rubber trees are twelve years old and planted 17 feet apart.

The growth of the cacao and rubber trees is very poor, considering their age. The soil is a heavy clay, and the surface very hard and compact. A chemical analysis of the soil has been made and the results are given below.

A sample of soil from the experiment plot at Louis d'Or estate contained, per cent. :—

Pebbles and sand	8
Fine soil	92

The air-dried fine soil contained, per cent.:—

Water	3·22
Organic matter and combined water	7·96
Mineral matter	88·82

The percentage composition of the fine soil, dried at 100° C., was :—

Organic matter and combined water*	8·225
Soluble silica	0·713
Oxides of iron and alumina	19·432
Lime	2·924
Magnesia	0·238
Potassium oxide	0·130
Sodium oxide	0·131
Phosphoric anhydride	0·149
Sulphuric anhydride	Nil
Chlorine	0·005
Insoluble silica and silicates	68·053
*Containing :—	
Total nitrogen	0·215

The available plant food found was, per cent.:—

Potassium oxide	0·0060
Phosphoric anhydride	0·0493
Nitrogen as nitrates	0·0013

Experiments under the Board of Agriculture.

The Board of Agriculture of Trinidad and Tobago was established by Ordinance No. 35 of 1908. It consists of the Governor as President, the Director of Agriculture as Vice-President, and from twelve to twenty members, appointed by the Governor, representing the agricultural industries of the Colony.

The formation of the Board of Agriculture was due to the voluntary offer of the planters to have their crops taxed for the purpose of employing experts who would be under their control. This offer having met with the warm approval of the Secretary of State and the late Governor of Trinidad, Sir Henry Moore Jackson, the Board of Agriculture Ordinance was framed, and passed by the Legislative Council on June 15, 1908.

By Ordinance No. 34 of 1908, the Board was empowered to raise a fund in aid of agriculture, by imposing a tax upon several kinds of produce grown and manufactured in the Colony.

The Board has control of its own funds, which are at present raised on cacao, sugar, cocoa-nuts and copra exported from the Colony. The rate of taxation is fixed by the Board from year to year, and submitted to the Legislative Council for approval.

The rates fixed for the period from January 1 to December 31, 1912, are as follows:—

On cacao at the rate of one penny for every 100 lb.
Sugar at the rate of 2½*d.* for every 1,000 lb.
On cocoa-nuts at the rate of 2½*d.* for every 1,000 nuts.
On copra at the rate of 7½*d.* for every 1,000 lb.

And in each of the above cases on lesser quantities in proportion.

It is estimated that a sum of $17,000 to $18,000 will be raised during the year as follows:—

On cacao	50,000,000 lb. at 2c.	per 100 lb.; say		$10,000
„ sugar	90,000,000 „ at 7c.	„ 1,000 „	„	6,300
„ cocoa-nuts	19,000,000 nuts at 5c.	„ 1,000 nuts	„	950
„ copra	2,436,000 lb. at 15c.	„ 1,000 lb.	„	365
		Total		$17,615

These funds are employed chiefly in providing experts for dealing with insect fungus and other pests, for making experiments and research, for collecting such information as the Board may think important for the purpose of agriculture, and for the collection and distribution of agricultural statistics.

All accounts of the Board are submitted to, and audited by, the Auditor General.

In February 1911, it was decided to carry out a series of manurial experiments on cacao, cane, cocoa-nut and cotton estates, situated in various parts of the island, and the first of these will receive attention. Arrangements were made for carrying them out on nine cacao estates. The manures are supplied free of cost to the proprietors, at their railway station, but the cost of application, as well as the cost of general cultivation, is borne by the estate owners.

The nature of the experiments is as follows:—

	Manures applied, per tree.	Cost of manures per tree. (Landed in Port-of-Spain.)
1	2 lb. basic slag ½ „ sulphate of potash	c. 2·85
2*	2 lb. basic slag ½ „ sulphate of potash ½ „ sulphate of ammonia	4·37
3	2 „ basic slag 1 „ nitrate of soda	3·84

	Manures applied, per tree.			Cost of manures per tree. (Landed in Port-of-Spain.)
4	2 $\frac{1}{2}$- $\frac{1}{2}$-	,, ,, ,,	bone meal sulphate of potash sulphate of ammonia	c. 5·27
5	1 $\frac{1}{4}$- $\frac{1}{4}$- 75	,, ,, ,, ,,	bone meal sulphate of potash sulphate of ammonia pen manure	7·02
6	1 $\frac{1}{2}$- $\frac{1}{2}$-	,, ,, ,,	superphosphate of lime sulphate of potash nitrate of soda	4·03
7	3	,,	lime	1·00
8**	3 1	,, ,,	lime superphosphate of lime	2·54
9	$\frac{1}{2}$- $\frac{1}{2}$-	,, ,,	sulphate of potash sulphate of ammonia	2·85
10	$\frac{1}{4}$- $\frac{1}{4}$- 75	,, ,, ,,	sulphate of potash sulphate of ammonia pen manure	5·43
11†	1$\frac{1}{2}$ $\frac{1}{2}$- $\frac{1}{2}$-	,, ,, ,,	superphosphate of lime sulphate of potash sulphate of ammonia	4·40
12‡	2 1	,, ,,	bone meal calcium nitrate	5·25
13‡	2 1	,, ,,	bone meal calcium cyanamide	5·79
14‡	50	,,	mulch	12·31¶
15‡	50	,,	pen manure	2·67

* Sulphate of potash and sulphate of ammonia applied two months after basic slag.

** Superphosphate of lime applied two months after the lime.

† Applied on two estates.

‡ Applied on one estate only.

¶ Includes cost of cutting, carrying and spreading.

The cacao experiments are being made with trees of various ages and in different soils as shown below.

Name of estate.	District.	Nature of soil.	Approximate elevation.	Rainfall Jan.—Dec. 1810.	Date manures applied.	Age of trees.	Shade.
Santa Marta ..	Tamana ...	Heavy clay, hilly ...	300 feet	**	May 1911	20 to 25 years	Irregular bucare
Esperanza ...	California ...	„ „ flat ...	25 „	67·10 ins.	June 1911	8 to 9 „	Regular „
New Grant ...	Princes Town	„ „ undulating ...	250 „	90·88 „	May 1911	10 to 11 „	„ „
Santa Teresa ...	Cumuto ...	„ „ flat vega	200 „	**	May 1911	About 40 „	Fairly regular „
Perseverance ...	Talparo ...	„ „ „ „	150 „	111·27 „	May 1911	30 to 40 „	„ „ „
La Compensacion	Caroni ...	Clay loam „ „	100 „	**	May 1911	55 to 60 „	„ „ „
Santa Isabella ...	Brasso ..	Loam, undulating ...	200 „	93·35* „	April 1911	20 to 25 „	„ „ anauca
Soconusco ...	Santa Cruz ...	Sandy loam, flat valley	150 „	87·06* „	May 1911	Over 50 „	„ „ „
Montrose ...	Chaguanas ...	Clay loam, flat valley	30 „	73·48* „	May 1911	40 to 50 „	„ „ „

*Rainfall on adjoining estate.
**No Rainfall record taken on these or adjoining estates.

The area under experiment on each estate is approximately 6 acres, or 54 acres in all.

The cacao trees are planted 12 feet by 12 feet, except at Esperanza where they are at a distance of 14 feet by 12 feet, and at Santa Isabella 13 feet apart. When the cacao trees are planted 12 feet by 12 feet, the immortel trees are generally 24 feet apart; that is at every two rows.

As these experiments have only lately been inaugurated, no records of yields are as yet obtainable.

The manures were spread broadcast to within 3 feet of the trunk of each tree, about 2 feet from the edge of the drains, and the soil forked up to a depth of about 6 inches.

Where pen manure was applied it was forked into the soil and the artificial manures were spread over it.

The number of plots on each estate varies from nine to fourteen, two of which were only forked and no manures applied. These are kept as control plots.

Records of pickings are to be kept from September 1 to August 31 of each year.

A copy of the forms supplied to the planters for forwarding the results of each picking is given below.

CACAO EXPERIMENTS.

Name of estate

Date of reaping

Plot.	Trees.	Number of pods.	Remarks.*
1	Full bearing ... Halves ..		
2	Full bearing ... Halves ...		
3	Full bearing ... Halves ..		
4	Full bearing ... Halves ..		
5	Full bearing ... Halves ...		
6	Full bearing ... Halves ...		
7	Full bearing ... Halves ...		
8	Full bearing ... Halves ..		
9	Full bearing ... Halves ...		
10	Full bearing .. Halves ..		
11	Full bearing ... Halves ..		
12	Full bearing ... Halves ...		
13	Full bearing ... Halves ...		

* Please state if any trees have died, and from what cause.

Weight of wet cacao picked from all the plots ... lb.
Weight of dry cacao from previous picking ... lb.

A NOTE ON THE BARNARD CACAO POLISHER.

BY J. C. MOORE,

Agricultural Superintendent, St. Lucia.

In these days of keen commercial competition it is essential that products, especially those used for food purposes, should possess with unvarying uniformity those particular qualities for which they are esteemed by the buyers, if they are to create and maintain in the open market a demand at the best prices.

It is, however, not uncommon for an article to possess every quality of intrinsic value and yet fail to secure the best prices, simply because it lacks that attractive finish, which, while adding nothing of actual economic value to the product, is nevertheless regarded with sufficient importance to give it precedence over the product that is less attractive though otherwise equally good.

The 'dancing' or 'polishing' of cacao during the curing of the bean is one of those processes for which a certain economic value is claimed, but it is probable that the real advantage of the process lies in the fact that an attractive and uniformly polished sample commands a better price than a dull, unattractive one, although it may be equally good in every respect but outward appearance. Growers in St. Lucia find that polishing pays, and on all estates the cacao is danced or polished, generally in iron sugar tayches, by the naked feet of labourers.

Now that cacao-polishing machines have been invented, it is probable that they will soon supersede the old-fashioned dancing and 'rubbing' methods, particularly on large estates where bulky crops have to be handled. On the smaller estates, too, they will no doubt come into use when suitable hand machines are obtainable at prices not prohibitive.

The dancing, either in heaps on the drying floor or in tayches by means of the naked feet, is regarded by some as a dirty process, though under proper supervision such as exists on most estates of any pretensions, it is not obvious why it need be any dirtier than that of dough-kneading by hand in the process of breadmaking.

The use of machine polishers will satisfy the popular mind as to the question of dirtiness. What is of more importance to the producer is the fact that the work can be done more rapidly and the polish produced is more uniform and thorough. The inventor of the Barnard machine also claims that the work can be done more cheaply, and this point in favour of the machine polisher is the more marked as the quantity of the cacao to be treated increases. Where labour is scarce or expensive, the machine would prove specially useful.

The Barnard cacao polisher occupies a ground space of 8 feet × 3 feet, and consists of a hollow cylinder made of wood or iron, through which runs a shaft on to which are keyed a number of eccentrics; attached to the lower or under side of these eccentrics are feet or pedals, jointed to give a rocking motion as the eccentrics rise and fall. Hard rubber pads are attached to the bottom of these pedals, which give under pressure to prevent the beans

from being crushed; an additional safeguard against crushing is that the pedals do not come within 2 inches of the cylinder, and are spaced sufficiently far apart on the shaft to allow the cacao to stir about freely and become thoroughly mixed as the pedals rise and fall alternately.

The cylinder and shaft are run in opposite directions, so as to ensure the thorough stirring of the beans, in order that each bean shall get an equal amount of polish. The cylinder is driven at the rate of ten revolutions per minute, and the shaft at sixty to eighty. At this rate of work the machine polishes 1 bag (200 lb.) of cacao in ten minutes—a record unobtainable by the present method, using the human foot. The Park machine is driven by belting from the 2½h.p. engine which drives a Gordon's Patent Drier of 8 bags capacity, but the patentee has arranged for hand gear to be attached to smaller machines (of 2 or 3 pedals) to be worked by one man.

The cacao is fed to the polisher and damped (just as at present) before starting, and on removal is placed either in the sun on trays, or direct into the drier.

To the machine at Park, extra gearing has recently been added, with the result that it is now possible to polish 450 lb. of beans with the same sized cylinder; and the time occupied in charging the machine with this quantity from baskets, polishing, and emptying all at one time into a large box arranged to slide on skids into position under the machine, is ten minutes. One man can attend to the machine for charging or emptying. When a full charge is put in, from 2 to 4 quarts of water is used in sprinkling the beans, but the exact quantity required to ensure a good and lasting polish depends considerably upon the dryness of the beans at the time of working. The quicker the beans are dried after leaving the polisher, the better is the polish retained. A little practice will soon render the operator perfect.

I have had several opportunities of seeing this machine at work, and am convinced that it supplies a long-felt want and that the extended use of this or other makes of polishers on cacao estates is only a matter of time. With a drier or polisher, the cacao planter can be independent of the weather, and turn out uniformly bright and attractive produce.

THE STRUCTURE AND POLLINATION OF THE CACAO FLOWER.

BY G. A. JONES,

Assistant Curator, Dominica.

Before giving a brief account of the observations and experiments which have been carried out at the Dominica Botanic Station with the object of determining by what means the cacao flower is pollinated, a short description of the structure of the flower itself may not be out of place.

In several respects the flower of the genus Theobroma is peculiar. The calyx is normal, and consists of five polysepalous petaloid sepals. The five petals of the corolla are very much contorted. Each petal forms a hood which usually encloses the stamen and terminates in a roundish appendage of a yellow colour. The androecium consists of ten stamens, united together at the bases; only five however are fertile; the remaining five produce no anthers. The five fertile stamens are opposite to the five petals, and as is stated above, are enclosed and protected by them. The structure of the fertile anther is quite different from that of the ordinary form of anther. Each anther does not, as is usually the case, consist of two anther lobes with two hollow chambers or pollen sacs running lengthwise in the interior of each lobe; but each anther lobe consists of two distinct pollen sacs, and the pollen sacs are placed end to end on the connective, always however remaining distinct, so that a complete stamen appears to consist of a filament bearing two double-celled anthers. On dissecting the flower, just before it is about to open, a furrow will be seen running lengthwise down the middle of each of the four pollen sacs. It is along this furrow that each pollen sac is ruptured, about two hours after the opening of the flower, exposing and liberating the pollen grains. This method of exposing the pollen grains is very effective, but were it not for the protection given by the petals, would lead to much waste of pollen during heavy rainfall. Each pollen grain is a minute round body, of a light colour. The amount of pollen produced is comparatively small.

The gynoecium is normal, consisting of five carpels joined together. The style is five-cleft. Sometimes the clefts remain in contact with one another, but usually spread apart. There is no apparent change in the style indicating the period of its receptiveness; whether the clefts remain in contact with one another, or otherwise, seems to have little or no effect upon its receptiveness.

The majority of the flowers open during the early morning. A short time after the opening of the flower, the pollen grains are set free. The stigma is receptive at the time of the opening, and remains so until the end of the second day. If pollination and fertilization do not take place (as is usually the case) during the first or second day, the flower drops off by the morning of the third day. This statement is supported by the following experiment, which was carried out early in September. A branch of a cacao tree bearing a number of flower buds was care-

fully labelled on a certain day : by the following morning a dozen or more flowers had opened ; two were hand-pollinated at once, two later in the day, two early the following morning and two in the afternoon ; the remainder were kept under observation but all those not pollinated dropped off during the night following the second day. Of those pollinated, one of the two pollinated on the morning of the first day, both those pollinated on the afternoon of the first day, and one of the two pollinated on the second day in the afternoon, were fertilised, and set fruit.

The above general introduction to the structure of the flower enables an account to be given of observations and experiments which have been conducted in Dominica, at various times for a period extending over several months, with a view of making clear as far as possible the means by which the cacao flower is pollinated in the field It must be stated however, at the outset, that the question is one of considerable difficulty, owing to the fact that of the large number of flowers produced by a cacao tree the number pollinated is very small. An attempt has been made to ascertain the percentage of pollinated flowers on the number of flowers produced under conditions in Dominica. This varies considerably with individual trees: in one case, of the 137 flowers counted on a stem, two were found to have been pollinated—a percentage of about 1·4. It must be stated, however, that this figure is much above the average: subsequent experiments show a percentage of 0·5 to be nearer the actual fact. Wright, in his work on cacao, states that he found that 0·2 to 0·4 per cent. of the flowers produced developed into mature fruits. This being the case, it is apparent that negative evidence is of but little value. We may place a flower under certain conditions and find that it falls off, but it does not follow, having regard to the above fact, that the flower would not have behaved differently under some other conditions: that is, it is difficult to prove the effect of modified conditions on the behaviour of a flower when the results obtained are negative. The difficulty can only be overcome by repeating the experiments a large number of times. This is claimed to have been done; though the experiments and observations will be continued for a further period.

The actual means of pollination in the cacao flower may now be considered. Flowers in general are pollinated usually by one or other of the following means: (1) insects, (2) wind, (3) some mechanical means, or (4) simple self-pollination.

The structure of the cacao flower makes self-pollination almost impossible. The anther is so completely enclosed by the petals that it would be difficult to imagine the pollen escaping and reaching automatically the style or stigma. Further, if self-pollination were the means, it would be fair to expect a few at least of the many flowers which have been enclosed to be pollinated. As will be seen later, in no single case had pollination taken place.

Very close examination has been made as to the possibility of pollination being accomplished by a mechanical process, say at the time of opening of the flower, or by the withdrawal of the petal. But nothing of the sort seems to occur, and had nature

adopted such a mechanical means it would actually be reasonable to expect a much higher percentage than 0·5, of self-pollinated flowers.

Again, the structure of the flower is quite unsuited for wind pollination. The anthers are not found to be exposed to the wind, and versatile, but are most carefully concealed in the petal. Pollen grains are not produced in large quantities: the reverse is actually the case; only a comparatively small amount is produced. The surface of each pollen grain is such that several are usually found clustered together; when pollen is adapted for wind-pollination the surface is usually dry and smooth. Again, the stigma is not by any means adapted to catch the pollen; it is smooth and devoid of hair. Further, in experiments performed, the evidence is against the probability of wind-pollination. Several groups of flowers have been enclosed within a spacious cage covered with muslin. Light breezes could easily reach the inside of the cage and might be expected to waft the pollen grains about, if these were easily transported, and one would naturally expect to find a few of the flowers to be pollinated, were this the method in nature. But such is not the case, and in no instance was a pollinated flower found.

The matter therefore arrives at the only remaining means of pollination: the one by the agency of insects. But at first sight, one is disappointed. The visits of bees, moths, butterflies, beetles or flies are sought for in vain: marked contrast exists between the scene in a lime or orange grove and that found in a cacao orchard. There is no sweet smell, no sugar nectar, in the case of cacao, and consequently it affords no attraction to the class of insect mentioned. On closer examination it is found, however, that the stalks of the flowers and the flowers themselves are frequently covered more or less with small insects such as mealy-bugs, thrips and aphis; these insects will be found to be carefully nursed by several species of ants, but more especially by the red ant. The question arises as to what relation, if any, exists between the cacao flower, these small insects and the ant. To try to elucidate this, numerous experiments and observations have been made. Large numbers of flowers have been enclosed singly by making a wire frame to prevent crushing, and covering this with fine muslin. These flowers were quite free from insects of all sorts. In no single case was pollination effected. This appears to show that without the aid of some outside agency, pollination cannot take place. The next series of experiments was with flowers which had a number of small insects on the stems, or where these insects were introduced by hand. The flowers were enclosed in a similar way, every care being taken to exclude ants, and examination two days later usually showed that the attempt at keeping out the ants had been successful. Again, in no single case was pollination brought about, though the insects had crawled to different positions on the flowers. This, together with the fact that insects found on cacao flowers, on being collected, chloroformed and examined under the microscope for the presence of pollen grains on their bodies and legs, failed to show any signs of the presence of pollen grains leads one to the conclusion that in Dominica these small insects have very little if any direct power of producing pollination of the cacao flower.

Further, were pollination affected solely by this means, as has been claimed by some authorities, one is somewhat at a loss to explain the undoubted crossing that goes on between trees of different varieties in a cacao orchard, the locomotive power of these insects being distinctly limited.

After close and continued examinations, and on carefully weighing the evidence, one is led to the conclusion that in Dominica the cacao flower is largely pollinated by the agency of ants, which are attracted to the flower by the secretions of the insects named above, and in the process of nursing these insects, come in contact with the pollen and transfer it to the stigma. The ant is known to be a carrier of the spores of parasitic fungi from one tree to another, it also seems highly probable that it aids materially in the pollination of the cacao flower.

In presenting this paper, it is not claimed that the question of the pollination of the cacao flower has been settled; but it is hoped that it will bring forward a discussion on a subject about which very little seems to be known at present, and that it will cause a problem which is full of interest and possibilities to be taken up by others.

CACAO EXPERIMENTS IN BRITISH GUIANA.

BY

PROFESSOR J. B. HARRISON, C.M.G., M.A., F.I.C.,
Director,

F. A. STOCKDALE, M.A., F.L.S.,
Assistant Director and Government Botanist,

and

S. H. BAILEY,
Superintendent, Onderneeming Industrial School, Department of Science and Agriculture, British Guiana.

A brief description of the British Guiana Government's experiments with cacao may be found on page 156 of the *West Indian Bulletin*, Vol. IX, in a paper dealing with Cacao Experiments in British Guiana, in which the results of the trials up to and including 1907 were recorded.

That paper showed that during four years prior to the removal of the greater part of the shade trees which up to 1900 were thickly growing on the fields, the mean annual yield of cured cacao was 1,064 ℔. whilst during the succeeding six years it increased to an average annual yield of 1,870 ℔. Since then the annual yields have been as follows :—

Year.		Cured cacao, lb.
1908		4,380
1909		4,790
1910		5,600
1911		5,000
	Mean	4,942

The increases in the crops are very noticeable and well illustrate the effects of lessening the shade on cacao when accompanied by adequate tillage and satisfactory drainage.

The proportions of the soil constituents which are regarded as being of importance agriculturally are shown on page 157 of the paper already alluded to. The analytical results led to the expectation that application of potash salts and of phosphates was probably necessary for the successful growth of cacao on the soil.

The mean returns of the four years' trials were given on page 159 of the paper, and the following deductions were drawn from them :—

That on the soils on which the trials were conducted the manure which exerted a favourable influence in the yields of cacao was a mixture of superphosphate of lime and sulphate of ammonia. Sulphate of potash was not indicated as being required, and in fact, little good resulted from its application. Nor did the use of sulphate of ammonia by itself prove satisfactory.

At the end of the paper the following opinion was expressed:—

Experience with cacao indicates that to obtain reliable results the plots used must be relatively large ones, containing at least 100 trees on each, and that each trial should be repeated on at least three plots and preferably on four or five. Then the mean results obtained over a series of crops, although probably not in any way striking, may be accepted as fairly reliable.

Prior to entering on another course of four years' trials, the results recorded from each plot of the former trials received very careful consideration. It was found that on plots $\frac{1}{3}$-acre in area with an average of ninety-five bearing trees on each over a period of four years the possible maximum errors on single plots had been 36 per cent. in excess and 27·6 in deficit of the mean yields of triplicate plots. The following were deduced from the results, the mean yields of each series of three plots being taken as 100 :—

	Yield per cent. of mean.	Probable error of mean result of each series.
No manure. Plot 1	129	
„ 2	95·6	
„ 3	74·7	± 8·7 per cent.
Nitrogen only		
Plot 1	136	
„ 2	99·7	
„ 3	72·4	± 10·1 per cent.
Potash and phosphates		
Plot 1	101·6	
„ 2	11·35	
„ 3	83·1	± 5·1 per cent.
Potash, phosphates and nitrogen		
Plot 1	115·5	
„ 2	108	
„ 3	76·3	± 6·7 per cent.

Hence over a period of four years the error on a single plot of approximately 100 cacao trees on absolutely flat, fairly well-drained land had amounted to as much as 32 per cent. in excess or deficit of the mean yield of three plots, whilst the maximum probable error found on the mean of three similarly treated plots was 10·1 per cent.

The mean results of the various series of experiments taken as percentages of increase on the mean yields of the unmanured plots were as follows:—

Plot series.	Mean increases on plots, yield of not manured taken as 100.	Probable error of mean result of each series.
Not manured		± 8·7
Potash and phosphates	6·2	± 5·1
Nitrogen	1·2	±10·1
Nitrogen and potash	8·7	± 8·5
Nitrogen and phosphates	23·7	± 2·9
Potash, phosphates and nitrogen	8·7	± 6·7

As the excess yields, to give reliable results, must have been more than the sum of twice the probable error on the not-manured series together with the amount of the probable error on the series under consideration, only the series manured with nitrogen and phosphates gave increases sufficiently high to allow of any deductions being drawn therefrom ; the other indicated increased yields were of about the same magnitude as, or were less than, their own probable error.

Early in 1908 the trial plots were re-arranged in the hope of reducing the extent of the probable error of the control plots, and of making the results of some of the others more strictly comparable than they were previous to that year. The plots were all laid out on one field instead of, as in the former series, partly in one field and partly in another, a broad path separating the two fields. In the first series of trials there was a probability of differences in drainage facilities affecting the relative yields of the plots. In the second all are practically alike in that respect. Five plots distributed regularly through the field form unmanured control plots, the liability to error in the mean of their returns being half that of duplicate plots, and in round figures about two-thirds of that of triplicate plots.

The very favourable results which have been reported as obtained by the use of very heavy mulching in a series of single plot trials in Dominica rendered it desirable to ascertain whether similar results are obtainable in British Guiana. Three plots distributed about the field were utilized for this purpose. These plots received each year very heavy dressings of leaves, grasses, weeds, prunings etc. from nearby fields, the cost of their collection and application being estimated at $16·00 to $18·00 per acre per annum. The practice of lightly mulching all the cacao fields has been followed consistently ever since the cultivation of the fields came under the control of this Department in

the financial year 1898-9. This of course would lessen the probability of any marked results arising from the heavy mulchings.

The beds comprising the plots were divided so that each formed two oblong beds containing approximately fifty bearing cacao trees on each part. This was done for two purposes; (1) for a trial of the effects, if any, of lining the land, and (2) to enable us to ascertain the relative liability to error of plots of $\frac{1}{3}$-acre and of plots of $\frac{1}{6}$-acre each. Even on the almost perfectly flat coast lands of British Guiana it is difficult to obtain areas of more than 6 or 8 acres over which the variations of soil, drainage etc., are so slight as not to interfere more or less with the reliability of cultivation trials. If we found that the liability to error on $\frac{1}{6}$-acre plots with fifty trees was not approximately higher than on $\frac{1}{3}$-acre plots with 100 trees, our agricultural experimental work with cacao would be materially facilitated.

The first year's results—those of the crop of 1909—showed that the range of probable error for single plots $\frac{1}{3}$-acre in area was ± 30 per cent., whilst for plots of $\frac{1}{6}$-acre it amounted to $\pm$ 55 per cent. The mean probable error on a series of five similarly treated $\frac{1}{3}$-acre plots was in round figures $\pm$ 4 per cent of their mean yields, whilst on the $\frac{1}{6}$-acre plots it was approximately 7·5 per cent. The wide range of variation, due doubtless to the marked individuality of the various trees, showed that it is useless to consider in any detail, or to base any conclusions on, the results of a single year's trials with cacao.

Over the three crops—1909, 1910 and 1911—the results on the five manured plots were as follows:—

Plot No.	Pounds per acre of Pulp.	Pounds per acre of Cured cacao.
1	3,170	1,141
4	3,364	1,211
7	3,750	1,350
11	4,147	1,493
16	2,678	1,324
Means	3,622	1,304

The above indicate a range of variations in the plots of 448 lb. of pulp per acre from the mean yields of the five plots, equal to $\pm$ 13·4 per cent. of that yield. The probable error of the yield of any single plot in the series is 252 lb. of pulp per acre or practically $\pm$ 7 per cent. of the mean yield. The probable error of the mean results of the five plots is 113 lb. equal to $\pm$ 3·1 per cent. of that mean. As compared with the probable error incidental to trials with sugar-cane as ascertained for a period of sixteen years, the accuracy of trials with cacao on the land such as that at Onderneeming where five $\frac{1}{3}$-acre plots with 100 bearing trees each are used, is practically the same as that obtained on our standard-sized plots of $\frac{1}{28}$-acre, on which about 150 stools of sugar-canes are growing, when using the same number of plots.

From the $\frac{1}{6}$-acre plots the following results were recorded :—

Plot No.	Pounds of pulp per acre. A.	B.
1	3,410	2,380
4	3,100	3,218
7	2,500	4,936
11	4,404	3,816
16	3,320	4,085
Means	3,347	3,687

Here the range of divergence of the results of single plots from the mean results is + 1,278 lb. of pulp or 34·6 per cent., the probable error of a single plot result being 423 lb. of pulp per acre in the A series, and 670 lb. on the B series, equivalent to $\pm$ 12·6 and $\pm$ 18·1 per cent., respectively. The probable error of the mean results of series A is 189 lb. of pulp per acre or $\pm$ 5·6 per cent; whilst that of series B is 300 lb. or $\pm$ 8·1 per cent. If the whole of the results are considered as from one group of similarly treated plots, the probable error of their mean would be 136 lb. per acre or $\pm$ 3·8 per cent.

The above deductions imply that, using single plots of $\frac{1}{6}$-acre for trial—a proceeding which it is difficult to believe could now be adopted by any agricultural experimental station even under such exceptionally favourable conditions as are there existent at Onderneeming—an increased yield of at least 36 per cent. of that of the reference plot must ensue in order that any reliance could be placed on the results of the trials. When five plots are used, the increase on the mean yield of the control plots by that of the plots which it is desired to compare with it must be at least 16 per cent. before it is allowable to attach any significance to it. If the control plots were increased in number to ten similarly treated plots of $\frac{1}{6}$-acre each, the probable error of their mean results would be in excess of that of the mean results of five control plots each of an area of $\frac{1}{3}$-acre.

It is clear from the above that areas of $\frac{1}{6}$-acre carrying fifty bearing trees even under very favourable conditions are too small for use in comparative trials with cacao.

No further reference will be made in this paper to results obtained on plots of this size.

The following shows the mean total crops of the variously treated $\frac{1}{3}$-acre plots over the period 1908-11, calculated to pounds of cured cacao per acre :—

	Cured cacao, ℔. per acre.
No manure	1,304 ± 45
Very highly mulched	1,738 ± 55
Sulphate of ammonia	1,249 ± 106
Superphosphate of lime and sulphate of potash	1,630 ± 76
Superphosphate of lime and sulphate of ammonia	1,498 ± 184
Sulphate of potash and sulphate of ammonia	1,378 ± 117
Superphosphate of lime, sulphate of potash and sulphate of ammonia	1,497 ± 31

The greatest yield of cacao has been on the very heavily mulched plots, where a mean increase of about 330 ℔. of cured cacao has ensued. To obtain this amount of cacao, worth locally about $40, has however cost at least $50 for the collection and application of the mulchings.

The application of superphosphate of lime and sulphate of potash resulted in a mean increased yield of 205 ℔. cured cacao per acre. The cost of the manure and the expenses of its application were in round figures $10 per acre; the value of the produce was $24 per acre.

The yields of plots to which sulphate of ammonia was applied either by itself or with the addition of phosphates and potash were less than the yields of corresponding plots not manured with nitrogenous manures. It is clear that, on the soils at Onderneeming, applications of readily acting nitrogenous manures are not desirable in cacao cultivation.

As in the previous series of trials, the application of superphosphate of lime and of sulphate of ammonia resulted in much higher yields than did the use of the purely nitrogenous manures.

From the general results of the two series of trials it appears that manurings with potash salts probably are not requisite on the Onderneeming soils.

The results of the application of lime — 2 tons of Barbados slaked lime per acre—have not been appreciable. Eighteen plots dressed with lime yielded at the rate of 4,116 ℔. of wet cacao per acre, whilst eighteen plots not limed produced at the rate of 4,084 ℔. per acre.

The cacao trees growing at Onderneeming are almost entirely of the Criollo and Forastero types, the very great majority of them apparently being hybrids of these varieties. Coloured drawings of the fruits, prepared by Miss van Nooten, of this Department, were shown at the meeting for presentation at which this paper was drafted. Whilst there are few kinds of cacao in

the fields at Onderneeming School farm there are numerous varieties, sub-varieties and hybrid kinds grown on the various cacao plantations in British Guiana; over fifty of them having been recorded by means of coloured drawings similar to those shown.

Some excuse may be desired for our having drafted a paper dealing with cacao to be read at an Agricultural Conference in Trinidad. Our excuses are that we have been occupied with experimental field work with cacao during the past twelve years, that one of us has from time to time frequently been consulted with regard to the selection of artficial manures for the cacao tree since in the early eighties he worked out the composition of a cacao manure (T.S.G. Cacao Manure*) for use in Grenada and that from time to time much attention has been paid to agricultural questions in connexion with cacao in the laboratory under the charge of one of us.

* This manure gave the following analysis :—

	Per cent.
Ammoniacal nitrogen	2·5
Organic nitrogen (from blood etc.) ...	2·5
Total nitrogen	5·0
Phosphoric anhydride... ... ... (soluble and reverted)	7·0
Potash	8·7

and was made up of :—

Sulphate of ammonia	2½ cwt.
Dried blood etc.	5 ,,
Superphosphate of lime (33 to 35 per cent. 'soluble phosphate'	9 ,,
Sulphate of potash	3½ ,,
	20 cwt.

SUGAR.

A COMPARISON OF SOME SEEDLING SUGAR-CANES WITH THE BOURBON VARIETY, IN BARBADOS.

BY J. R. BOVELL, I.S.O., F.L.S., F.C.S.,

Superintendent of Agriculture, Barbados.

So much has been written lately about the value of the Bourbon sugar-cane as compared with seedling sugar-canes, that I propose to give briefly the results obtained in Barbados during the past fourteen years with that cane, the White Transparent and the seedling canes B.208 and B.147.

The Bourbon sugar-cane was cultivated in Barbados almost exclusively up to the end of 1894. At the close of 1895, owing to the short crop made that year, due mainly to the fungus disease *Colletotrichum falcatum*, a number of planters commenced to grow the White Transparent and seedling varieties in substitution for the Bourbon. In a comparatively short time, with few exceptions, all the planters were growing these canes. It may therefore not be without interest if I compare the results obtained with the Bourbon cane, the White Transparent and the

seedling canes B. 208 and B. 147 grown in the same field under the same conditions for the past fourteen years, so as to obtain some idea not only of their respective values, but also the value to Barbados of the sugar-cane experiments carried on there. This experiment was carried out at Dodds in the parish of St. Philip, at an elevation of about 210 feet above the sea-level, and the average rainfall for the period was 56·39 inches. Care was taken each year only to use sound, healthy cuttings obtained from plant canes for replanting the plots. In spite, however, of all the care taken to plant only apparently healthy cuttings, the Bourbon has each year with one exception, been more or less attacked by the fungus *Colletotrichum falcatum.*

The following table gives the results obtained for the fourteen years, in pounds of muscovado sugar, on the assumption that every 100 lb. of saccharose in the juice was equal to 80 lb. of muscovado sugar of 89° test, and its molasses. The value of these two products has been calculated at the average price at which muscovado sugar and molasses sold during those fourteen years namely $1·72 per 100 lb. of sugar and 13·7 per wine gallon of molasses, less the cost of manufacture.

Kind of cane.	Average yield of muscovado sugar for 14 years, lb.	Increase on Bourbon.			Increase on White Transparent		
		Sugar* per acre, lb.	Per cent.	Value. †	Sugar* per acre, lb.	Per cent.	Value. †
				$ c.			$ c.
Bourbon	3,571	...	...	...	...	...	...
W. Trans.	4,634	1,063	29·8	22·45	...	...	...
B. 208	4,936	1,365	38·2	28·82	302	6·5	6·38
B. 147	5,763	2,192	61·4	46·28	1,129	24·4	23·85

*Muscovado sugar.

†Less cost of manufacture.

As will be seen from the table above, during the fourteen years, the sugar-cane which did best, namely B.147, yielded sugar and molasses, after deducting the cost of their manufacture, of the value of $46·28 more than the Bourbon cane, the B. 208, $28·82 more and the White Transparent $22·45 more. As compared with the White Transparent, which was the cane that

was principally substituted for the Bourbon, B. 147 yielded 24·4 per cent. more sugar, and B. 208 yielded 6·5 per cent. more.

Some of the planters in the neighbourhood of Dodds, finding from the results of the small experiment plots, which they instituted on their estates with some of the seedling sugar-canes, that the results obtained with these varieties were better than those of the White Transparent, with which they had mainly replaced the Bourbon, gradually substituted the better of the seedling varieties for the White Transparent, until they ceased cultivating that cane. It may not, therefore, be without interest if I give the results obtained in Barbados, on a fairly large area at Carrington, an estate in the neighbourhood of Dodds, for the four years 1903-6, which were as follows:—

Variety of sugar-cane.	Acreage of canes reaped for the four years.	Dark crystal sugar per acre, lb.	Increase of dark crystal sugar on W. Trans.	Value of dark crystal sugar with its molasses, per acre per annum.
				\$ c.
W. Trans.	396·5	5,134	...	102 20
B. 208	23·5	5,485	351	109 19
B. 147	125·0	5,949	815	118 42

The value of the sugar has been calculated at \$2·05 per 100 lb. plus 8c. per wine gallon for the dark crystal vacuum pan molasses, less 22c. per 100 lb. of sugar—the cost of manufacture. The average quantity of molasses at Carrington is about 45 wine gallons per ton of all sugars.

On the assumpton that the Bourbon had been grown at Carrington during the four years and that the yield had been in the same ratio as the yield at Dodds, the yield of the Bourbon would have been 3,956 lb. of dark crystal sugar and the value, with its molasses, at the above prices, would have been \$78·75 per acre.

For the four years, therefore, the value of the increased yield per annum of the White Transparent, the B. 208 and the B. 147 over the Bourbon would have been \$23·45, \$30·44 and \$39·67, respectively.

The average results obtained at Dodds and Carrington estate are briefly as follows:—

Variety of sugar-cane,	Increase on Bourbon,		Average.
	Dodds.	Carrington.	
	\$ c.	\$ c.	\$ c.
W. Trans.	23·45	23·46	22·95
B. 208	28·82	30·44	29·63
B. 147	46·28	39·68	42·98

From the above table it will be seen that the average revenue, per acre, of the B. 147 over the Bourbon cane at the two estates based on the ratio of the Bourbon to the White Transparent at Dodds was \$42·98 (£8 19*s*. 1*d*.), of the B. 208 over the Bourbon \$29·63 (£6 3*s*. 5½*d*.), and of the White Transparent over the Bourbon \$22·95 (£4 15*s*. 7½*d*.). It will also be seen that the average revenue per annum of the B. 147 and B. 208 over the White Transparent was \$20·03 (£4 3*s*. 5½*d*.) and \$6·68 (£1 7*s*. 10*d*.), respectively. I need hardly add that the White Transparent is not now grown at Carrington and some of the neighbouring estates on which the canes are weighed and the juice analysed. It is but fair, however, to add that owing to the B. 147 proving a poor ratooning cane in Barbados, it is not a suitable sugar-cane for the whole island. It is probable that its place will be taken by B. 6450, a variety which has in recent years given exceptionally good results as plant canes in the black soil districts and as plant and ratoon canes in the red soil districts.

It may be mentioned incidentally that during the past ten years, several of the planters have endeavoured to grow the Bourbon sugar cane in Barbados, but in every case, so far as I know, it has been attacked by the fungus *Colletotrichum falcatum*, and the experiments have ended in failure. At the present moment there are two plots of Bourbon sugar-canes growing on one estate from plants obtained from Panama, and for a long time they were free from disease. On my visiting this estate a few days ago (January 1912), I found the fungus *Colletotrichum falcatum* present in one of the plots.

In conclusion, may I suggest to those who are continually advocating the growing of the Bourbon sugar-cane, without what appears to me sufficient data, to grow for some years that sugar-cane and the seedling or other sugar-cane found to be doing best in their neighbourhood, under the same conditions, and compare the results, so that there may be something definite in future on which to base their advice.

MANURIAL EXPERIMENTS ON SUGAR-CANE IN TRINIDAD AND TOBAGO.

BY J. De VERTEUIL, F.C.S.,
Assistant Analyst, Government Laboratory, Trinidad.

Manurial experiments on sugar-cane are being made on four estates. These experiments are under the control of the Board of Agriculture.

The manures are supplied free of cost to the proprietors at their railway station, but the cost of application as well as that of general cultivation is borne by the estate owners.

The following experiments are being made on plots of approximately 1 acre each :—

	Manures applied, per plot.	Cost of manures, per plot. (Landed in Port-of-Spain.) $ c.
1	2 cwt. sulphate of ammonia ... 1 ,, bone meal ... ... ½ ,, sulphate of potash ...	10·08
2	2 ,, sulphate of ammonia ... 1 ,, ,, ,, potash ...	9·80
3	3 ,, calcium cyanamide ... ½ ,, sulphate of potash ...	10·26
4	4 ,, calcium nitrate ... ... 1 ,, superphosphate of lime	11·00
5	2 ,, nitrate of soda ... ... 2 ,, basic slag	6·90
6*	2 ,, nitrate of soda .. ... 10 ,, temper lime	8·95
7*	2 ,, sulphate of ammonia ... 1 ton temper lime (air slaked)	14·21

There are nine plots on each estate, two of which are treated with the manures generally employed by the estate authorities.

*The nitrate of soda and sulphate of ammonia were applied to plots 6 and 7, respectively, two months after the lime.

The nature of the soil and variety of canes planted are given below.

Name of estate.	District.	Nature of soil.	Approximate elevation, feet.	Rainfall Jan.-Dec. 1910, inches.	Variety of cane.	Date when planted.	Date when manures applied.
						1910.	1911.
Frederick	Caroni	Flat, clay loam.	25	129·76*	D. 109	Oct.	June
Esperanza	California	Flat, sandy loam.	25	67·10†	B. 156	Nov.	June
Union Hall	San Fernando	Undulating black loam.	80	75·05	D. 109	Oct.	May
Malgretout	Princes Town	Undulating red loam.	80	74·78	B 156	Oct.	June

* Average rainfall for ten years is 90 inches.
† ,, ,, ,, ,, ,, ,, 56 ,,

At Frederick and Esperanza Estates, the fields under experiment had received applications of pen manure at the rate of about 10 and 5 tons per acre respectively, previous to their selection for the experiments.

No pen manure had been previously applied to the fields at Union Hall and Malgretout.

The area under experiment on each estate is approximately 9 acres, or 36 acres in all.

The canes will be reaped during the coming crop season, and the weight of canes from each plot recorded.

BOURBON AND SEEDLING CANES.

BY J. W. ARBUCKLE,

Brechin Castle Estate, Couva, Trinidad.

My experience of the Bourbon cane dates from 1873, at which time, it was practically the only cane grown in Trinidad. It was a good cane both in field and factory, doing equally well as plant cane, on black and red soils It, however, ratooned longer in black than in red soil, and gave a better return in ratoon canes. At that time canes were not weighed on the estates, making it impossible to compare weights of cane per acre, as can be done at the present time.

The Bourbon cane showed signs of its vitality being impaired in the year 1896, and two years later it was attacked seriously by root fungus. Single canes in a stool would become dry at the top, and shoots coming from the joints of the cane, on either side would wither up and the cane would fall over. Another would be affected in the same way, and so on until the stool would be ruined.

By way of experiment, I began to uproot the affected canes and burn them when weather permitted; failing this, I had a trench, 6 feet × 4 feet dug, into which the diseased canes were put and covered over with 2 feet of earth.

The disease spread so rapidly that whole fields died out; it was impossible to carry on the experiment. As soon as crop began, I had those fields burned off, replanting them the following year with healthy Bourbon plants taken from another section of the estate, miles away, where no disease existed, and using only top plants. The germination was good, also growth as high as 4 feet, when symptoms appeared, similar to those of the previous year; single canes dried up and fell over, until the whole stool was gone.

Strange to say, the diseased canes buried 2 feet deep in the trench, sent through shoots, and grew into healthy stools of ten to twelve canes, never showing the least sign of the same disease. The canes were cut, and ratooned very well for one year.

The following two years were trying ones, Bourbon canes giving out, and seedling cane plants impossible to get in any quantity. I resorted to the White Transparent cane, planting this on the fields where the Bourbon had given out, and reaped from 40 to 55 tons canes per acre. As this is not a good cane in the factory, in sucrose content or as fuel, I gradually reduced the acreage as I increased that of other varieties of seedling canes.

In 1904, I gave the Bourbon cane another trial by using two fields in different parts of the estate—fields that had been in seedling cane cultivation for four years, that is in plants and first and second ratoons, giving a good return each year, and never showing the least sign of disease. I selected only good, healthy top plants, treated them with Bordeaux mixture, and, after they had germinated fairly well, applied pen manure at the rate of 15 tons to the acre, and later on, artificial manure at the rate of 3 cwt. per acre. They were well cultivated, but when about four months

old showed symptoms of disease identical with that of 1898, and gave a return of only 17 tons per acre. The spring of first ratoons looked so weak and poor that I ploughed the field.

The second field which I treated in the same way as that first mentioned gave better results, with a return of 23 tons per acre; the yield from first ratoons was 7 tons per acre.

These two fields were replanted in seedling canes, and gave a return of 40 tons per acre, with practically the same treatment as the Bourbon had received.

In 1906, I gave the Bourbon another trial, planting 30 acres. This land was steam-ploughed, harrowed, making it fairly level on the surface, and subsoiled to a depth of 16 to 18 inches and again harrowed, thus making a fine tilth. Bourbon cane plants were brought from the Caroni estate, new land, and planted in furrows measuring 5 feet × 2 feet. Germination was fairly good. When the plants were two months old, 15 tons of pen manure per acre was applied; when they were four months old, 3 cwt. of artificial manure per acre was used. When they were between five and six months old, the plants showed signs of the same disease, single canes drying up and falling over, until the 30 acres were practically ruined. The result of the experiment was *nil*, as the canes were not fit to be sent in to the factory. The remainder of them were cut down and burned in order to clear the land for replanting.

The same area was planted with seedling cane, D. 116, and I reaped 32 tons of cane per acre.

In June 1911, as another trial, I planted 6 acres of Bourbon, the plants being brought from Caroni estate again—I have never tried Bourbon from any other source than Trinidad. These plants are now about six months old, and have had an application of pen manure, 15 tons per acre, at the time when planted: no artificial manure has been applied. At the present time the plants look sickly, and the growth has been checked for the last two months. Judging from present appearance, the result will be on a par with those of the experiment of 1906.

After the three above experiments, with their results, one can hardly be blamed for abandoning the Bourbon cane; though, I might almost say, the Bourbon cane abandoned me. I have no hesitation in saying that had I persisted in trying to cultivate this cane, the estate, of which I have the honour to be manager, would have been abandoned long ere now. We read in the local press, from time to time, under the heading Weather and Crops, that the cane farmers are in favour of the Bourbon cane. It would be interesting to know the acreage of Bourbon and of seedling canes in cultivation in the hands of the farmers.

I presume that the disease of the Bourbon cane is similar in result to the disease of English potatoes, in Great Britain. New varieties had to be resorted to, as the old were not worth cultivating, on account of disease, although the soil is subjected to rotation of crops.

The seedling cane, in Trinidad, has been a friend to the sugar planter for the last twelve years at least. This statement the majority will admit, I think.

The following varieties have been of great service on the Brechin Castle estate :—

D. 95	D. 116	D. 625
D. 109	B. 347	B. 156.

The first-mentioned, D. 95, was our best cane for four successive crops, as plants, first ratoons and second ratoons ; unfortunately, it seemed most susceptible to froghopper in 1906. All the other varieties have been tried on a large scale, and found to do well. At the same time no variety is immune from the froghopper. The damage for the present year is considerable, and unless a remedy can be found, we are liable to a recurrence of this pest at any season. What puzzles one is that small blocks of land in different sections of the estate become seriously attacked, while fields of cane in close proximity are quite healthy—free from froghoppers. Then these blocks which are attacked for one year may be free from froghoppers the following year. What we do require is a greater variety of seedling canes, and, if possible, a better disease-resistant cane or canes. I understand that the Department of Agriculture is looking into this need, and that the raising of seedlings has already been started ; if so, I hope they may be successful in producing some new varieties, even better than any we have at the present time.

In conclusion, I can say that the return of sugar per acre on the Brechin Castle estate, since I planted only seedling canes, has not decreased ; on the contrary, it has increased.

THE APPLICATION OF MENDELIAN PRINCIPLES TO SUGAR-CANE BREEDING.

BY F. W. SOUTH. B. A. (CANTAB.),

Mycologist and Agricultural Lecturer on the Staff of the Imperial Department of Agriculture for the West Indies.

It may be definitely stated at the start that this paper is of an entirely theoretical nature, and aims only at a consideration of the possibility of applying to the case of the sugar-cane the more modern methods of producing improved races of plants. These consist of utilizing the principles of the inheritance of definite unit characters as set forth originally by Mendel and elaborated by Bateson and his school.

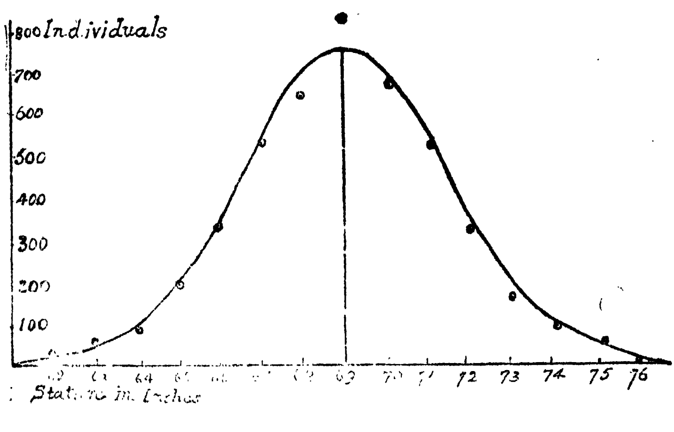
The depression in the West Indian sugar industry that occurred in the latter half of the last century was to some extent the outcome of competition with the subsidized product obtained in Europe from the sugar-beet. This competition was only rendered possible by the cumulative effect of many years of well directed artificial selection of superior varieties of the beet. A recognition of this led workers in the West Indies to attempt a similar improvement in the case of the sugar-cane, in which they were fundamentally assisted by the rediscovery of the fertility of sugar-cane seed. The possibility of producing hybrids furthered the work of selection in two ways. It provided an increased

number of variants upon which selection might work; and it opened up the possibility of combining in one cane characters of a desirable nature that were formerly distributed among two or more strains. More importance was originally attached to the first method, particularly as it was then believed that hybridization resulted in the production of greater variation in the offspring than could be expected in those resulting from the inbreeding of more definite and fixed strains. At the same time the possibility of combining two or more desirable characters in one cane was not overlooked, while in recent years it has received ever-increasing attention. Yet in spite of this, such a combination in the case of the sugar-cane is always a matter of chance, and few attempts have been made to obtain it in accordance with quite definite laws, nor even to discover if such laws exist. A discussion of the possibility of producing synthesized canes in accordance with definite laws is the principal object of this paper; but before considering this it is necessary to pass shortly in review our present knowledge of the nature of variation and of its inheritance, because this knowledge has increased to a remarkable degree in recent years, and because it lies at the very root of all methods of improving the characters of cultivated plants.

Variation is now recognized to be of two kinds: true variation due to differences in the germ cells from which the individual variants have arisen; and what is often called 'fluctuation', which embraces differences between adult individuals that are brought about by the environment to which these have been exposed during their growth. True variations are inherited, while fluctuations are not, except when the environment has a direct disturbing action on the germ cells themselves in addition to that exercised on the development of the bodies of the individuals. True variation itself may be divided into continuous and discontinuous variation, the latter being often known as mutation. It may be noted that mutation is applied by some to the act of variation, by others to the product of the act. Here, this term will be kept for the act itself and the term Mutant will be applied to the individual arising by mutation. Individuals exhibiting continuous variation show an evenly graded series varying about a mean: those exhibiting discontinuous variation may be divided into sharply defined groups. Continuous variation is believed to be due to indefinitely numerous small causes, and the degree of its inheritance is variable and indeterminable in advance in any given instance. Discontinuous variation is supposed to be due to the operation of one, or at the most a few, definite determinable factors, and its inheritance usually obeys certain fixed laws. Fluctuation may occur in connexion with either form of variation, but the offspring of a self-fertilized mutant are said to breed true when they exhibit a continuous series of forms only differing from one another within a range that can be accounted for by fluctuation. It is only when discontinuous variants arise in the offspring that a mutant is said to be impure or not to breed true. This explains from one point of view what is meant by breeding true, while it may be amplified to explain the meaning of the term Pure Line. Another method of arriving at the meaning of these terms will be considered later. At the present moment it seems advisable to give simple examples to illustrate the mean-

ing of the terms continuous and discontinuous variation, since a proper comprehension of these, particularly of discontinuous variation, is essential to the understanding of the principles of Mendel's laws.

If the heights of all the men of any given country be measured, it will be found that the values obtained vary between two extremes, for example 60 to 76 inches, and that all intermediate values occur. That is, the character of height exhibits continuous variation. Moreover, there will only be a few individuals with heights of the extreme values, while those of the greatest number will have the mean value of about 69 inches. If equal increments of length are marked off along a horizontal axis, each of which shows a unit increment of height of, for example, 1 inch, and if from each point so obtained a perpendicular is drawn showing by its length the number of individuals having the height indicated by the point from which it is drawn, then on joining the tops of all these perpendiculars a smooth curve will be obtained. This will have its apex at the mean value of the height, that is 69 inches. The vertical line from the apex of the curve to the horizontal is called the mode, and in this case it indicates the number of individuals having the mean height of 69 inches. The type of curve obtained is shown in the following diagram :—



If again, the heights of all the sons of fathers of a definite height be plotted in the same manner, it will be found that they also vary continuously, but they do so about a mode that lies between the mode for the whole race and the perpendicular to the original curve at the point indicating the height of the fathers. Thus they do not vary about the height of the fathers, but about a height between this and the modal value of the whole race. This phenomenon is known as regression, and is a constant property of continuous variation : it is attributed to the influence of generations prior to the fathers on the variation of their sons.

If, on the contrary, the heights of two strains of plants, one tall and the other dwarf, were treated in the same manner, not one, but two curves would be obtained, each varying about a separate mode, and the two strains would be said to exhibit

discontinuous variation, The series of forms occurring in each strain would be due in all probability to the action of both continuous variation and also of fluctuation, but in spite of the continuous variation in the separate strains each would be quite distinctly marked off from the other. Further, each strain would breed true, in the sense that the offspring could always be definitely recognized as belonging to one strain or the other. Now, suppose that the tallest individuals of the drawf race were as tall as, or taller than, the shortest of the tall race, then a continuous curve would be obtained with two maxima or highest points in it, yet the variation would be in reality discontinuous. By elaborating this idea it is possible to understand how a large number of separate strains, each varying continuously about a mode very near that of the nearest strain on either side might be mistaken for one strain exhibiting continuous variation only. Instances are actually known of such step mutations, as they are called, in which an apparently evenly graded series is in reality composed of several discontinuous strains each varying continuously about a different mode. Their existence may be demonstrated by growing the offspring of one individual representative of several of the strains, when it will be found that the offspring obtained from each parent vary about the mode of the strain to which the parent belonged. When the offspring vary in this way the strain may be said to breed true. Care has been taken here to explain the sense in which the terms 'breed true', and 'pure race' or 'strain' are used, because the observation that no individuals produce offspring exactly like themselves, that is breed absolutely true, is sometimes used in an attempt to discredit the Mendelian theory. This argument is in reality based on ignorance of the sense in which the terms referred to are used, and is entirely without value.

It has been shown that the inheritance of continuous variation is subject to regression but that of discontinuous variation is quite different. When the discontinuous variant or mutant form is pure bred, all its offspring will be pure in the sense that no new mutants will appear during the first few generations, though naturally, if this process is continued for some time, one or two new mutant forms may arise, in the manner in which the original strain itself arose. But if the offspring are the result of a cross between two pure strains, the characters of each parent will be inherited in accordance with definite laws, both in the immediate offspring and in those obtained by self-fertilizing these offspring among themselves, while in the second generation new mutants may arise as a result of the rearrangement within them of characters inherited from either parent. This case may now be considered.

Mendel was the first to recognize that, in order to determine definitely the laws of inheritance, it was necessary to study first the manner in which only one pair of characters, one being the opposite of the other, was handed on to succeeding generations, when two individuals, each exhibiting one of the characters, were crossed with one another. The classical example with which he worked was the inheritance of tallness, and its opposite dwarfness, in peas. Two distinct strains occur in peas: the tall and the dwarf. He found that when tall individuals

were crossed with dwarf, all the offspring of the first generation were alike and were all tall. But, when these hybrid talls were self-fertilized or crossed among themselves, dwarfs appeared in the second generation plants. Moreover, he found that the dwarfs appeared in the definite ratio of one such to every three talls. When the second generation plants were self-fertilized it was found that the dwarfs produced only dwarfs, while some of the talls produced talls only, and some again produced dwarfs in the ratio of three talls to one dwarf; that is, that of the second generation talls one in three was pure bred and produced talls only, while the remaining two were hybrids like the plants of the first generation. Thus the first generation hybrids on self-fertilization actually gave rise to pure talls, hybrid talls and pure dwarfs in the ratio 1 : 2 : 1. The tall character which appears alone in the first generation is termed dominant, and the short character which disappears recessive. It is now generally held that dominance is due to the presence of some factor which is absent in the recessive.

This peculiar result Mendel explained on the hypothesis that a germ cell or gamete could only contain one of a pair of opposite characters, and that equal numbers of germ cells containing either character were produced by hybrid plants. Since equal numbers of such germ cells are produced by any flower of a hybrid, four possible arrangements of the gametes in pairs occur on crossing the hybrids among themselves, and three of these will contain the dominant factor while one does not. Thus if T represents tallness and t its absence—shortness, a gamete bearing tallness may be represented by T and one bearing shortness by t. Two tall gametes go to form a pure tall which may therefore be represented by T T, and similarly a pure short is represented by tt. The hybrids of the first generation are represented by Tt and each gives equal numbers of gametes T and t. Since both T and t may be fertilized by either T or t, the resulting second generation plants are represented by TT, Tt, tT tt, that is they occur in the ratio of one pure tall, two impure talls, and one pure dwarf. The process is represented graphically in the following diagram:—

TT   t t ..... parents

T × t ....parental gametes

T t ....F 1 plants

T × T : T × t : t × T : t × t ...F 1 gametes

TT   T t   t T   t t ...F 2 plants

This theory can be tested by crossing the hybrids with the recessive parent, when equal numbers of pure recessives and hybrid dominants should result, since the recessive parent produces pure recessive gametes only. This, Mendel found to be actually the case. Individuals that arise from the union of two germ cells each containing the same character are called homozygous, such are the pure talls and the pure dwarfs just considered; those arising from the union of gametes bearing different characters, so that each contains both members of a pair, are said to be heterozygous, such are the hybrid talls referred to above. Homozygotes breed true and give rise to a pure line; heterozygotes do not.

In addition to tallness and dwarfness, peas may vary in several other pairs of characters, as for example the colour of the flowers and of the seeds. Both green and yellow seeds are known, and it has been found that the green are recessive to the yellow. Mendel studied the inheritance of several such pairs, both singly and two or more at a time. The case of the inheritance of two pairs of opposite characters may now be considered. If a strain of tall peas with green seeds is crossed with a dwarf strain having yellow seeds, the resulting first generation heterozygotes will all be talls with yellow seeds, since these are the dominant characters. These give rise to four different kinds of gametes, and since any one gamete has a chance of meeting any of the other four, all possible combinations of the four gametes will arise. The way in which the combinations arise is shown graphically in the following diagram :—

TTyy		ttYY	...	parents
Ty	×	tY	... ...	parental gametes
	TtYy		... ...	F 1 plants

	T Y	T y	t Y	t y
T Y	T T Y Y	T T Y y	T t Y Y	T t Y y
T y	T T Y y	T T y y	T t Y y	T t y y
t Y	T t Y Y	T t Y y	t t Y Y	t t Y y
t y	T t Y y	T t y y	t t Y y	t t y y

(Column heads: F 1 gametes)

Thus if T indicates tallness and t its absence, dwarfness, Y yellowness and y its absence, greenness, the F_1gametes will be TY, Ty, Yt, yt. These give on their union all possible combinations, 4Tt Yy, 2TtYY, 2TTYy, 1TTYY ; 2Ttyy, 1TTyy ; 2ttYy, 1ttYY ; 1ttyy. All those that contain both T and Y will be tall with yellow seeds; of these there are nine; three contain T and y and are tall with green seeds; three contain t and Y and are dwarfs with yellow seeds; and one contains only t and y and is a dwarf with green seeds. Only the forms TTYY, TTyy, ttYY, ttyy are homozygous for both characters, and in every sixteen plants only one of each form appears. Those of the form TTYy, TtYY, ttYy, Ttyy are homozygous for one character only, while the remaining forms are heterozygous for both. The homozygous forms will breed true on self-fertilization, so that in three generations it is possible to produce two new strains which breed true, namely tall plants with yellow seeds and dwarf plants with green seeds ; the dwarfs with green seeds are simple to establish since they have both recessive characters only, and therefore all plants in the second generation which exhibit these characters cannot contain dominant characters and can be relied upon to breed true at once, while in order to establish any of the other pure strains it is necessary to self-fertilize all the plants exhibiting the two desired characters, in order to determine which individuals breed true and which do not.

This method of producing new types containing any two members of two pairs of opposite characters may be extended to cases where more pairs of characters are concerned; so that ultimately a plant containing several desirable characters could be built up, and undesirable characters could be eleminated. There are certain exceptions to this statement due to a phenomenon known as coupling, but they need not be dealt with here.

Thus Mendel's researches into the inheritance of opposite characters exhibiting discontinuous variation have resulted in the discovery of a precise method whereby a strain exhibiting in itself several chosen characters may be synthesized from several strains each possessing one of the characters.

In some instances an apparently simple character, as for example flower colour, is in reality due to the action of two or three or even more factors; if two strains of which this is true are crossed together, the first generation plants will give a colour probably unlike either parent and determined by the interaction of the various dominant factors present. In the second generation. obtained by self-fertilizing or inter-fertilizing the first generation plants, a very large number of different colours may appear owing to the redistribution of the determining factors. These colours may appear to form an evenly graded series, such as is characteristic of continuous variation, and it is only when the number of factors present has been determined that the production of the colours in accordance with Mendel's laws, and therefore the true discontinuous nature of their variation can be firmly established.

It has been urged by some that this definite method of synthesizing, in the course of a few generations, varieties combining in themselves characters originally distributed among different parent varieties, might advantageously be employed in the production of seedling sugar-canes. In the subsequent paragraphs some attention will be given to this suggesion manifested in an attempt to find out if there is any evidence now available relating to the nature, variation and inheritance of the different characters of the sugar-cane. This will be done by considering if any information may be obtained from past work and by discusssing shortly certain definite characters in their bearing on this subject. A few practical difficulties will be referred to and finally certain suggestions will be put forward by way of a conclusion.

There are one or two points that may be emphasized in connexion with the above discussion, before the case of the sugar-cane is considered. In the first place it is absolutely necessary to continue breeding for two generations in order to determine if any given characters will segregate on Mendelian lines. That is, the parents must first be crossed, and then the resulting offspring must be fertilized among themselves. If, however, one or both of the parents is itself a hybrid, then segregation will appear in the first generation plants, though its exact significance may be hard to analyse, unless details are known of the ancestry of the parent strains. Further, in order to establish the purity of a strain containing a new combination of characters it may be necessary to raise a third generation of seedlings by self-fertilizingthe different individuals of the second generation.

In the second place, when an attempt is being made to combine in one strain, by Mendelian methods, desirable characters from two or more strains, it is necessary to deal with those that exhibit discontinuous variation, and to commence with strains pure for the characters dealt with. When the cross has been made no attention need be paid to the first generation hybrids; it is only in the third generation that the success or failure of the attempt can be determined with absolute certainty, unless all the desirable characters are dominants, and even then the first generation plants exhibiting these will not breed true.

Lastly, very thorough analysis of a series of forms is necessary before it can be determined if these exhibit continuous or discontinuous variation.

In considering the case of the sugar-cane, there is one fact which is of fundamental importance in connexion with the nature of its variation, and the inheritance of that variation, namely that it is most frequently propagated vegetatively. Now vegetative propagation is in its essence merely artificially increasing the size of an individual until it covers a very large area. No really new individual is produced except by the act of fertilization; and Mendelism, depending as it does on the distribution of characters among the germ cells, is entirely without application to vegetative reproduction. Differences may arise among vegetatively produced plants in three ways. The very various external conditions to which the individuals so produced are subjected may cause fluctuation over a wide range; of this nature are the differences in the sugar-cane seedling B.208 noted by Professor Harrison when this cane is grown on different soils. Such fluctuations, as stated above, would not be expected to breed true, and disappear on transferring the canes exhibiting them to a different environment. This is practically what happens when individuals of B.208 grown in one locality are used as cuttings in another. Thus individuals exhibiting a fluctuation of this nature in the direction of an increased sugar content in one locality could not be expected to retain with certainty the same increase in that content when transferred to different surroundings. Continuous variation may apparently occur also in vegetatively reproduced individuals; and mass selection when exercised on this variation would result in a gradual improvement in the characters selected.

Sudden well-marked mutation may take place, such as is occasionally found in localized parts of many plants. This would reappear in individuals grown from the part exhibiting it. Very possibly bud variation may be of this nature. Such mutations would give rise to new strains, breeding true to the mutant character on self-fertilization or when the individuals exhibiting it were reproduced vegetatively.

To these two categories belonged the differences which were made use of in the early selection experiments on sugar-cane. When the rediscovery of the fertility of cane seed began to be made use of, the position was somewhat changed. At the time of the discovery Mendelism was unknown, and knowledge of the nature of variation was not nearly as advanced as it is now. In consequence the work conducted was along the somewhat haphazard lines then in vogue in all questions of plant-breeding,

and only little attention was paid to a knowledge of the exact parentage of the seedlings produced, so long as plenty of variable material could be obtained, upon which artificial selection might be exercised. Thus a large number of undoubtedly hybrid seedlings were produced, whose ancestry was entirely unknown, while no light was obtained on the question of inheritance in the sugar-cane, or on the nature of the standard types then known. Of recent years more and more attention has been directed towards the production of seedlings of known parentage and ancestry, but since this work has gone hand in hand with a rigid selection of types exhibiting desirable agricultural characters, and since all other forms have been discarded, these seedlings, coming as they do from forms of unknown parentage, not many generations removed, do not provide much evidence for solving the question of what are and what are not characters subject to discontinuous variation, nor to elucidate the manner of the inheritance of these. It is however possible that the rigid selection that has been exercised in favour of a few characters may have tended to produce strains of sugar-cane breeding fairly true to given values of those characters ; on the other hand, the continued crossing must, to a certain extent, have lessened the effect selection would have brought about if exercised on vegetatively produced individuals or those originating by self-fertilization only. This is so because mass selection of this kind tends to separate out a pure strain that fluctuates or exhibits continuous variation, as the case may be, about the maximum modal value of the character selected. This effect would be slightly impaired by the complications introduced by crossing, yet it would seem that it operates to some extent since Kobus found that seedling sugar canes are less liable to variation than are the older strains. It has been noticed that seedling canes resulting from any given cross are not exactly like one another, nor do they tend to fall into a few well marked groups with respect to the agricultural characters usually recorded. This is however no definite evidence of continuous variation in these characters, because the parent plants, when known, are often likely to be complex hybrids in themselves, while the number of seedlings obtained from the given cross is too few, as a rule, for a clear recognition of the presence or absence of definite groups to be possible. Another factor which has operated against any advance in the past in our knowledge of inheritance in the sugar-cane, is the extent to which all the regular botanical characters, with the possible exception of colour, have been omitted from the records of characteristics of seedling and other canes. A further point that renders the old records of little value in solving the question of inheritance is that there is no absolute proof that the same seedling has not been produced several times in the same and in different localities, and given a different number on each occasion. Thus on the whole, it may be stated that there is as yet no definite evidence to show the nature of the variation of different characters of the sugar-cane, nor to shed any light on its inheritance, so that it cannot be said whether any given pair of characters is or is not likely to show segregation when judged by evidence accumulated in the past. It is true that certain experiments along Mendelian lines were commenced by Stockdale and Bovell, but as far as the writer is aware no definite results

have been obtained, partly because of the few seedlings produced, and partly because the original parents chosen were themselves seedlings and were, therefore, likely to be somewhat complex hybrids, while no steps were taken to test their purity for the characters for which they were chosen. Thus, as there is but little evidence to be obtained from past records, it may be advisable to turn to a consideration of some actual definite characters, and to endeavour to ascertain from this consideration if there is any probability that any of them exhibit discontinuous variation and will inherit this in the manner described above.

The characters that have been most thoroughly studied are those of economic importance such as sucrose content of the juice, fibre content of the cane, tonnage of cane per acre, disease resistance and the like. The sucrose content of the juice appears, in considering the published records, to be subject to continuous variation; but at the same time, it is of a fairly constant value in certain seedling canes. It is naturally subject to considerable fluctuation in the case of individuals grown in different localities; while disregard of the probability that each variety has a definite period of maturity may account to some extent for differences that appear in records of its value in the same variety grown in the same locality in different years, since the canes may not always have been reaped when at about the same degree of ripeness, the results being therefore not strictly comparable. Again there is a possibility that this apparently single character is due to several causative factors varying discontinuously, and that the distribution of these among different seedlings has produced a series of forms apparently exhibiting continuous variation, such as is found in the case of colour inheritance in the sweet pea. Furthermore, to determine the continuous or discontinuous nature of the variation in this case, the value of this character would require to be measured by a more definite standard than is at present employed. The present method is subject to many complications, such as errors introduced by the drying of the cane before it is crushed, by the varying condition of ripeness of the canes, and others; consequently it is certainly not an accurate measure of the amount of sugar in the cell sap, and this is the character that would most probably behave as a Mendelian unit, not the somewhat vague result of analysis of juice obtained by crushing.

Tonnage of cane per acre is another character subject to very considerable fluctuation due to the influence of external conditions, while it also may arise from the interaction of several causes. It is not even a single character, since it may be due to several different characteristic conditions of the canes concerned. For example, the same weight of cane might be obtained by reaping a field of (a) long thin canes, with few shoots in a stool; (b) thick canes of medium length with few shoots to a stool (c) thinner canes of the same length with more shoots to the stool; (d) small canes with many shoots to the stool. Each of the above would be different sets of characters when regarded from the Mendelian view point. Thus tonnage of cane per acre is merely a categorical heading denoting the results arising from the interaction of several characters.

The question of disease resistance again is somewhat complicated. Resistance to disease in general is almost certain to be due to several internal causes; even resistance to one specific disease may not be a simple character, while it may be connected with others such as the sucrose content of the juice and the hardness of the rind.

It would appear therefore, from a consideration of these characters of agricultural importance, that too little is known of their nature and of the manner in which they may react on one another, to permit of any judgment as to whether they are subject to continuous or discontinuous variation. At the same time it is fairly clear that the majority of them are of a complex nature and cannot be expected to segregate as Mendelian units. It is obvious, therefore, that no useful end can be served by the haphazard crossing of possibly hybrid strains of sugar-cane merely because they exhibit high values of certain economic characters.

A consideration of some of the neglected botanical characters, such as has been made the subject of a paper to be read by Mr. Sahasrabuddhe seems to indicate that certain of them do exhibit discontinuous variation, since the canes showing them fall into a few distinct groups. Such are the shape and nature of the eyebud, the presence or absence of a channel in the internode, the nodal characters, the method of rolling of the leaves—whether inwards or outwards, possibly their width and colour, and other similar points. The colour of the internodes may also vary discontinuously, from a broad point of view, so that canes could be grouped as yellow, purple or striped; but the smaller differences in colour are certainly subject to great fluctuation so that any discontinuous variation, if it exists in them, is almost entirely masked, while in the case of some seedlings this fluctuation covers a wide range of colours, as Professor Harrison has shown for B. 208.

One further character of a botanical nature that may well be subject to discontinuous variation is the fertility or sterility of the pollen. In peas this has been found to segregate in accordance with Mendel's laws, and the same might well be true of the sugar-cane. It would seem, therefore, that certain botanical characters might be expected to show segregation in their inheritance, and a study commencing with them might eventually throw some light on the inheritance of economic characters.

The practical difficulties in the way of progress in hybridization work with sugar-cane are very considerable. The artificial method of cross-pollination which ensures the preclusion of foreign pollen is at present a very laborious process, and gives rise to comparatively very few seedlings. Again the absence of fertile pollen in some varieties makes it difficult to self-fertilize them or to use them as male parents. While another point is that in dealing with economic characters, particularly the value of the sucrose content of the juice, some more definite standard than that now in use would require to be invented. These are some of the obstacles that would have to be overcome, and doubtless others would appear as investigations proceeded, but careful and patient work would probably find some way of dealing with them all.

After the consideration of the points that have been put forward, one cannot avoid the conclusion that, at the present time, there is very little evidence to indicate the nature of the variation exhibited by the different characters of the sugar-cane, and that there is absolutely no analytical knowledge of those that will behave as Mendelian units. Synthetic work yielding definite results in a definite number of generations is impossible under the circumstances, and haphazard experiments supposed to have this object are entirely outside the sphere of labour of experiment stations. It is folly to suppose that such experiments, unsupported by an adequate understanding of the characters concerned, could end in anything but waste of time and disappointment. Experiment station workers whose function it is to supply planters with economically useful forms of sugar-cane, should continue to work along the old lines. They certainly should not sacrifice the results obtained, and the stores of experience gained by years of labour, in favour of a doubtful method of synthesizing a hypothetical sugar-cane. On the other hand, the study of inheritance and the acquirement of the necessary analytical knowledge might well form the object of the work of one or more special stations situated in a locality where the sugar cane arrows freely, and where the conditions are as uniform as possible. These stations would not be required to produce economic results, and might well commence operations by an investigation of the nature and inheritance of botanic characters which are likely, as has been stated, to segregate in accordance with Mendel's laws. The line of investigation followed would be different from that in experiment stations at the present time. It would be necessary to test the different strains for purity of the characters chosen, by self-fertilizing them, and then to study the behaviour of the characters in exactly the same manner as Mendel did those of peas. When the method of inheritance of botanical characters had been determined, then it might be possible to form some opinion as to the nature of the inheritance of economic characters and to proceed to a study of this point. Even if economic attributes were found to be subject to continuous variation or to present in their inheritance a problem so complex as to render its solution of no value to agriculture, yet there can be little doubt that the work would not have been in vain. Many points of importance might be discovered in the course of it, while a true understanding of the nature, variation and inheritance of botanical characters would be of the greatest value in an attempt to arrive at a satisfactory classification of the various forms of the sugar-cane.

THE STUDY OF SUGAR-CANE VARIETIES WITH A VIEW TO THEIR CLASSIFICATION.

BY G. N. SAHASRABUDDHE.

It is a singular circumstance that though the sugar-cane plant has been, and is being, cultivated for so many centuries and in so many different countries, and though it has been made a subject of close study by so many scientists, yet there is one feature of the subject about which we have hardly any definite knowledge, at least as far as published information is concerned; I mean the classification of sugar-cane varieties. There is hardly any other instance of a species of so great an economic importance as *Saccharum officinarum* whose varieties have not been classified, at least in a tentative form. Not that no attempts have been made in this line. But those attempts have been extremely sporadic and incomplete. Not only the species officinarum, but the whole genus Saccharum, has remained in this state. Though we see this genus being divided into three or four species the specific characters have been loosely defined and the present grouping of the genus Saccharum into such species as *S. officinarum*, *S. sinense*, *S. violaceum*, etc., is hardly satisfactory. The idea of grouping the enormous number of sugar-cane varieties under one species—officinarum—has been especially objected to by some botanists, but no attempt to break up that species or at least to group the varieties under appropriate sub-species has been satisfactory. The chief difficulty appears to be in defining specific or even varietal characters. Previous to the discovery of the fertility of the sugar-cane seed this difficulty was practically insurmountable because in defining specific or broader varietal (or sub-specific) characters it is necessary to ascertain the common ancestors of the various varieties, but as long as the canes had to be propagated by vegetative methods this was practically impossible.

During this period, that is previous to the discovery of the sugar-cane seed, the usual way of classifying sugar-cane varieties was according to the colour. This method was in vogue even during the transition period, that is just after their discovery, but before the seedling varieties had come into prominence. The chief systems of classification based on the colour of the stem are those by Dr. Stubbs in Louisiana, by MM. J. de Cordemoy and A. Delteil, and by Professor Harrison and Mr. Jenman in British Guiana. During the eighties a large number of varieties was grown in the British Guiana Botanical Garden, and as a result of the study of these varieties, Professor Harrison and Mr Jenman devised another system of grouping the varieties. In their early system of grouping the varieties according to colour, they had five groups. But that grouping was entirely artificial, being based on one character only. But after studying several varieties grown side by side they arranged those varieties into eleven groups according to their appearence and the habits of their growth. But one cannot fail to notice that the colour has influenced the formation of these groups to a great extent.

But when the propagation of sugar-cane by seed was begun, it was found out that the offspring from the seed of the same

parent showed enormous variations in all directions, and since then the idea of considering every plant propagated by seed as a separate variety is prevalent. As a result of this, we now have many thousands of varieties of sugar-cane.

Before these seedling varieties were obtained, it was considered very nearly a physical impossibility to classify the few hundred that were available at that time. Now, how can we deal with these thousands of varieties, which might become millions in a short course of time? Is there always to remain a chaos in the sugar-cane world? Is it ever possible to trace the genealogy of sugar-cane and to arrange these ever-growing varieties in a systematic way? This is the question I want to bring before this Conference for discussion. I am a mere student and, too, a beginner in this subject. I have been studying this subject, during the last five or six years, but the literature to which I have had access is hardly elaborate enough even to satisfy a beginner. Occasionally, I come across casual statements discussing the variations in the characteristics of sugar-cane varieties but their disconnectedness precludes the obtaining of a clear idea. Valuable information is obtained by the perusal of the British Guiana Experimental Station Reports. In many reports) Professor Harrison and Mr. Jenman have discussed points which throw light on this question, but unfortunately such information is wanting in the later reports from British Guiana and the reports of other experimental stations, where hundreds of these varieties have been under close study for the last twenty years or more. A vast amount of information must have been accumulated in the brains of those who have spent their lives in the daily study of these varieties. But the outside world is still in the dark about the results.

In this Conference I see before me the originators of sugar-cane seed propagation, who have been god-fathers to thousands of varieties, who have studied these children of the sugar-cane family from their very birth. If we are not to look to such an unique assembly for the result of their researches and for definite and connected information on such a subject which has puzzled the world and which is far beyond the reach of outsiders and of casual observers like myself, to whom else shall we look for such information?

This is the object of bringing this question before this Conference, and the few points I beg to place before you are not for the purpose of offering any new things to you; for of this I am far from capable; but to elicit information which we, in other parts of the world, are looking for from the scientists of the West Indies.

In considering the sugar-cane varieties, it is important to see which of these are real varieties and which are mere causal variants. At present every sugar-cane plant grown from seed is designated as a variety. But it is quite evident that the word variety here is used in a different sense from that of real botanical varieties. Sugar-cane seed is evidently extremely liable to variations and at present in the propagation of seedlings every variant is called a 'variety', but it is certainly an interesting question to find out which of these are real botanical varieties. For this

purpose it is necessary to define varietal characteristics. What constitutes a variety? Evidently one having some definite characters which will remain constant to a great extent. Therefore it is necessary to find out what are such constant characters. Of course, by the present method of vegetative propagation of the sugar-cane, most of the characters are transmitted to the offspring including those which might not be constant when propagation is by seed. Even in the case of vegetative propagation some characters change, as in bud variation. Prior to the advance in seedling varieties, the origin of at least some of the older varieties had to be attributed to bud variation. Examples of canes of different appearance from the original stock, through bud variation, are quite common. In a stool of Red Ribbon cane that I examined in Antigua, I saw eleven shoots of which three were real Red Ribbon canes, four had the colour of a mixture of yellow and green with a few blank blotches, while four were green in colour with black blotches. The black colouring was removable by scraping, and therefore was not the colour of the rind. The girth of the stem varied, from shoot to shoot. The stems were very similar in their habit of growth. There was more bloom on the stems of ribbon canes than on those with solid colour. The eye buds were of the same nature. Had these canes been separated and propagated by cuttings, of course most of these characters would have been inherited by the offspring and thus would have constituted three separate varieties, in the present sense of that word. But, dealing with their general habit, one will have to consider them as one botanical variety, though the stems show a difference in colour. This has been a well-recognized fact and it is on this account that the eight or nine varieties such as White Transparent, Rappoe, Mont Blanc, Caledonian Queen, Naga B., Striped Singapore and Red Ribbon, are nowadays grouped under one heading: 'White Transparent and its Allies.' Here is an attempt to find out the real botanical varieties. Harrison and Jenman in their classification of the older varieties into eleven groups have gone in the same direction.

Is it not possible to look upon the seedling varieties from the same point of view? It can be readily seen that many of the seedlings hardly deserve the name variety in the botanical sense of that word. Can we not group these seedlings according to their proper varieties? Simply because a stem assumes a new colour or possibly changes in appearance in a few directions, the cane to which it belongs can hardly be said to constitute a new variety. Can we not say the same as regards the shoots obtained from seed of the same parent? Of course from what we know of the variations in seedlings from the same parent, such a question will appear very ludicrous. I quite admit that anybody who sees the tiny bits of reeds side by side with the giants grown from the seed of the same parent varying in colour and extremely varying in the composition of juice is liable to brush aside such a question as foolish. But are we to suppose that the sugar-cane plant violates Nature's law of inheritance?

It will be encroaching too much upon your time to go into details, and thus wasting the time which would otherwise be devoted to hearing your views, which is my only object in bringing this question forward; but in order to make my question

clear I might cite the law of mutations as laid down by Hugo de Vries in his Species and Varieties, Their Origin by Mutations :—

I. New elementary species appear suddenly without intermediate steps.

II. New forms spring laterally from the main stem.

III. New elementary species attain their full constancy at once.

IV. Some of the new strains are evidently elementary species, while others are to be considered as retrograde varieties.

V. The same new species are produced in a large number of individuals.

VI. The relation between mutability and fluctuating variability :—

Fluctuating variability as a rule is subject to reversion. The seeds of the extreme do not produce an offspring which fluctuates around their parents as a centre but around some point on the line which combines their attributes corresponding to their ancestors, as Vilmorin has put it.

No reversion accompanies mutations, and this fact is perhaps the completest contrast in which these two great groups of variability are opposed to each other.

VII. The mutations take place in nearly all directions.

It will ceretainly be very interesting to see which of the characters in the sugar-cane are subject to fluctuating variability. There is no doubt that the chemical composition of the juice, especially the maximum sucrose content, is subject to fluctuating variations and obeys the Quetelet Law, both in the canes propogated by cuttings and by seed. But if any other characters, morphological characters, are thus subject to fluctuating variations we do not know. In fact beyond the early observations of Professor Harrison and Mr. Jenman contained in the British Guiana Reports up to 1905, there is no definite information, at any rate in English literature, about the morphological variations due to seed propagation.

These questions can be studied only on the spot, and by those who can constantly watch the experiments year after year. Any conclusions drawn by one outside, who may have seen the varieties casually, or who has obtained information from published statements and description of the varieties can hardly be satisfactory. Unsatisfactory as these conclusions might be, even these are difficult to arrive at without detailed description of the varie ties, and the changes that have been noticed.

It is a striking circumstance that very few of the varieties have had accurate botanical descriptions. Now and then a controversy arises about the identity or otherwise of some varieties, but usually these points are decided by personal impression. With due respect to the scientists who have followed this method I cannot help making note that such a procedure is far from satisfactory. I venture to suggest that in the case of the doubts of the identity, and in fact as a general rule, it is far better to give accurate botanical descriptions of varieties. I mean botanical descriptions and not agricultural descriptions which are usually

to be found in the experiment station reports and text-books. These general descriptions serve the purpose for which they are intended, but they are quite inadequate for scientific study.

As far as I am aware, the only attempt towards the botanical descriptions of the varieties has been done by Mr. Mollison and Dr. Leather in their descriptions of the varieties grown in India. Even these descriptions fall short in some respects; yet they conclusively prove the value of such descriptions. With such descriptions at hand we can detect and record small variations which can thus be communicated to the outside world. Such a record of the varieties grown from time to time will be useful in tracing the variations in the individuals due to change of climate or soil, and also in the progeny. In the British Guiana Reports the colour of the stem of practically all the varieties is carefully recorded. But as has been abundantly proved by Professor Harrison, the colour of the stem is a variable function; some varieties, like B. 208, show an enormous range of colours and also shape of the stem, when grown in different soils. But if full botanical descriptions of these variants were available, it would have been possible to trace out invariable functions. Professor Harrison has had a large number of coloured sketches made of these variants. But I beg to suggest that, though coloured sketches are very useful, they require a good artist and they cannot be easily copied without considerable expense, so that they are not available to the outside world. Besides this, a coloured sketch represents one particular specimen, and unless the artist has some knowledge of botany, accurate delineation of some characters becomes difficult. After seeing the coloured sketches prepared by Miss Van Nooten in British Guiana, and the coloured plates given by Mr. Noël Deerr in his new book, one cannot help thinking that this way of recording the characteristics of a variety is hardly adequate, much less easy.

An accurate botanical description should include description of all the parts of the cane, whether some parts are at present considered important or not. Their importance might be found out at some later period. The plan adopted by Mr. Mollison and Dr. Leather in their description of Indian varieties is a good beginning in this direction. That plan can be amplified further. A typical description, I beg to suggest, should give us information on the following points:—

LEAVES. (1) *Colour*, and (2) *Breadth*.

[I have found that this breadth varies from 4 to a little more than 6 cm. In my notes I have tried to divide them into four groups: viz—*narrow* (below 5 cm.), *medium* (5 to 5·5 cm.), *broad* (5·5 to 6cm.), *very broad* (above 6 cm.).]

STEM. (1) *Shape*, whether (A) straight, with girth of internodes uniform throughout, (B) straight, but with girth of internodes decreasing towards top or towards top and bottom, or (C) girth uniform but stem zigzag; (2) the *Colour* of the stem; (3) *Height* of the stem.

INTERNODES —(1) *Shape*, i.e. whether (A) cylindrical, (B) bulging in the middle, or (C) constricted in the middle. Also whether a Channel is present or not, and if present whether

(A) broad and shallow, (B) narrow and deep, or (C) medium. Also (2) *Length* and (3) *Girth*.

NODES, which comprise :—

1. *The Ring*, whether distinct or indistinct, and if distinct whether superficial and coloured or colourless, i.e. same as ground colour of the stem and whether a ridge or groove.

2. *The Upper Band*, whether uniform in breadth or broader at bud ; the colour of this band.

3. *Root Dots*, whether distinct or indistinct, whether numerous or spare, and also whether arranged in definite rows either alternate or opposite or scattered indiscriminately.

4. *The Lower Band* (which is always covered with bloom). The size of this band as compared to that of the upper band, and its colour underlying the layer of bloom, which may or may not be the same as the colour of the stem.

EYE BUD. [I have found that an accurate description of the appearance of the eye bud is a difficult matter, especially in the case of hybrids, and to give a correct idea I think the description should be accompanied by a natural-sized photograph of the bud.]

Bloom. That is the grey, waxy layer. It is always present on the lower band of the node; but its presence or absence on the internode and also its thickness should be noted.

INFLORESCENCE. When the variety produces arrows, the appearance and structure of the inflorescence.

Such a description, if possible accompanied by a coloured sketch, or at least a natural-sized photograph of the node showing the *eye bud* in front, will give us all the data for tracing the variations in different varieties in different countries.

While preparing such a description and especially when selecting a node for taking the photograph of an eye bud, I have found that great care is necessary in selecting the specimen. The appearance of the eye bud, the presence or absence of channel and the prominence or otherwise of the root dots vary from node to node, according to the different stages of growth. The eye bud has different appearances on the stem on the upper, middle and the lower parts, even when the cane is near maturity. The upper buds are young and undeveloped, while the lower ones are over developed and probably have already begun to shoot. Sometimes, even when the variety is without a channel, a slight channel is found on the upper part, while in varieties always showing a channel it sometimes disappears on the lower part where the buds have already begun to grow. Specimens photographed without taking these points into consideration will give entirely misleading results and will end in disappointment. Many a photograph that I have taken has been spoiled for this reason. To give best results the specimen should be selected from the middle part of the stem where it is neither premature nor over mature. Care should be taken to ignore the buds which have begun to grow.

As we all know, different cane varieties show differences in all these parts. The point is to trace out which of these characters are constant enough to indicate botanical varieties or types of the

present agricultural varieties. It is evident that these characters, which are inherited by the progeny, even when this is grown from seed, are of utmost importance and it is on this point that definite information is badly wanting. Of the above characters, the colour and size of the leaf are evidently not constant characters for inheritance, though in vegetative propagation the leaves do not appear to change to any great extent. But the progeny by seed of a variety having broad, dark-green leaves does not necessarily possess this kind of leaves. Some will have medium, and dark or light-green leaves.

The colour of the stem in relation to inheritance has been a subject of elaborate discussion by Professor Harrison and Mr. Jenman in the early reports on experiments in British Guiana. But no information is available on this point from any other source. As far as we can see from the observations by Professor Harrison, in some varieties the majority of the plants propagated by seed inherit the colour of the parent to a more or less extent. Thus the majority of the seedlings from Bourbon resemble the parent in colour. In connexion with this question of colour, a remark by Professor Harrison and Mr. Jenman in their Report for 1893-5, concerning the striped canes is highly interesting. They say: 'The range of varieties in seedlings is far greater in those obtained from parents which are striped than among those which are derived from self-coloured canes, and this is true not only as regards colour, but also size and sugar content. Up to the present we have obtained no reliable clue to the origin of the numerous striped varieties, we have only obtained two seedlings showing this phenomenon : one from the Horne cane and the other from unrecorded parentage, and these were of so low a vitality that we were unable to preserve them.' Since this statement was made a few more striped seedlings have occurred in British Guiana, but none have come into experimental cultivation.

Now and again we see it asserted that the probable parent of several varieties is the striped cane. White Transparent and Purple Transparent are especially supposed to have originated from their striped ally. But since we know that solid-coloured canes are as capable of producing striped canes by bud variations as the striped canes are capable of producing solid coloured canes, and in view of the above remarks and also the fact that none of the seedlings from striped canes have shown stripes, is it not reasonable to suppose that the striped cane is the real sport? Had it been the original cane, at least a large number of the seedlings from Red Ribbon would have shown stripes. But the fact is quite the contrary.

The variations in the shape and size of the internodes have been quite evident in all cases. The chemical composition also varies, though as a general rule it can be said that seedlings from parents rich in sucrose content are also usually rich, or sometimes richer than their progenitors.

The structure and appearence of the inflorescence had been made an object of study by Mr. Jemman, and he has recorded the descriptions of the arrows of the older varieties which were under experimential cultivation in British Guiana. Similar descriptions for other varieties are badly needed.

There is, however, one part of the cane which has been practically neglected by all, except Mr. Mollison and Dr. Leather in India, and that is the morphology of the node including the eye bud. As canes have been propagated by the eye bud for more than two thousand years, is it unreasonable to suppose that the eye bud and the node with which it is intimately connected must have been highly developed in certain definite directions and must be playing an important part in stamping characters on the offspring? Just as the flowers of plants propagated from seeds are the most important and highly developed parts of those plants, and are therefore given their proper place in the classification of those plants, in the same way can we not assign the same position to the eye bud (and the node also) when considering the sugar cane? It was this question which prompted me to study this part more closely. My observations have been necessarily very limited for want of experience as well as for want of time, and I am taking this opportunity to place before you some of the points that I have observed, with the intention of ascertaining whether indications shown by these observations are not sufficiently strong to justify further close study.

Among the canes I have examined up to this time I have come across five kinds of eye buds: (1) Flat, broad, pointed, the point slightly extending beyond the ring with a distinct channel of medium breadth and depth. This eye bud may be best described as an obtuse-angled triangle on a semicircle. White Transparent presents typical examples of this kind of eye bud. Purple Transparent and Red Ribbon show the same kind of eye bud. The Green Ribbon eye bud comes very near to this, but it is more long than broad and the triangle on the top is acute. (2) Broad, somewhat flat, apex (bud-tip) more or less pointed but the channel is indistinct; when present the channel is broad and deep near the bud, but tapers and vanishes near the middle of the internode. The bud may be best described as an equilateral triangle. The bud-tip or apex of the bud in normal state never extends beyond the ring. A typical example of this is afforded by Bourbon. I am not quite sure whether to subdivide this type of eye bud into two sub-types according to the presence or absence of the channel. In some samples of Bourbon that I have examined in India and Antigua, I have seen that the channel was altogether absent, but otherwise the bud is exactly the same as in the Bourbon with a channel. I am not sure whether the presence or absence of a channel distinguishes the two types of Bourbon, or whether the occurrence of the channel is due to cultural circumstances. D. 625 presents another good example of a cane possessing this type of bud. (3) The eye buds of varieties like White Tanna and Honolulu come very near to this type, but instead of being an equilateral triangle they are more or less circular with the bud-tip on the top. But the question is whether to consider them as an entirely distinct type of bud or only a sub-type of the above. One thing which prompts one to consider it as separate is the change these buds undergo when beginning to shoot. The White Tanna type of eye bud becomes spheroidal, losing the point of the tip and then beginning to grow; whereas the Bourbon type of bud maintains the pointed tip, and elongates without first becoming spheroidal. (4) Long,

narrow, pointed, far extending beyond the ring, with a distinct deep channel. Examples of this type are Samsara, Elephant, Meligeli. (5) This type is very peculiar in appearance. It is circular in shape, without any channel, thus resembling the White Tanna type; but the broad tip instead of being on the top is nearly in the middle. The bud may be best described as Mammary. How far this is an original eye bud is doubtful. I have not as yet come across any of the older varieties showing this bud. There are a few cases amongst seedling varieties showing this eye bud. The best example I can show is that of D. 145, though I must point out here that several canes of D. 145 show an entirely different bud, which is triangular with a distinct but shallow channel which does not disappear in the middle of the internode. That the mammary bud, at least in D. 145, is a normal bud is shown by the two sports it has produced which exhibit this kind of eye bud distinctly, and further than that, D. 58, a descendant of D. 145, also shows the same kind of eye bud. That this appearance of the bud is not due to over-maturity I am perfectly satisfied. The White Tanna type of bud, which is the only one which we might expect to show this kind of appearance when it begins to grow, becomes spheroidal but still keeping the bud tip upwards. The parent of D. 145 is Red Ribbon, which shows a typical White Transparent eye bud. Whether D. 145 has got this peculiar eye bud, so different from that of its parent, because of a natural cross with some other variety, or whether this is a natural modification of the White Transparent eye bud, is a question well worth study.

That the eye bud is a constant character of each particular variety appears to be quite evident. I have carefully examined the eye buds of White Transparent, Red Ribbon, Bourbon, D. 625, B. 208, B. 147 and some other varieties, in different colonies, and in different places in the same colony, and they do not show any appreciable variation, provided the buds examined are normal, that is neither too young nor over mature. I have examined some of the variants of B. 208 which show wide differences in colour and shape of the stem, but as far as I have seen, the eye bud, and in fact the structure of the whole node, do not show any appreciable difference, except in some specimens grown on very heavy soil, which has stunted their growth to such an extent that the whole plant has become entirely abnormal.

There is also abundant proof that the structure of the bud remains constant in the case of bud variation where the colour of the stem changes entirely. I have already cited the case of bud variations from Red Ribbon that I have examined in Antigua I have here photographs* of bud variations of D. 145, D. 625 and White Tanna. In every case the buds are quite similar in appearance. The very examples of White Transparent, Red Ribbon, Purple Transparent and other canes which are supposed to have originated by bud variations (whichever we might suppose to be the original stock) all also show the same kind of eye bud, in fact the same structure of the node; so that, as far as

* Not reproduced. A plate showing the five types of eye bud will, however, be published with the *West Indian Bulletin*, later.—Ed., *W.I.B.*

vegetative propagation is concerned, the eye bud and the structure of the node may, on the whole, be taken as a constant character.

Does this hold true even in the case of seed propagation? This is the question on which only the most experienced can give an opinion. It is evident that the study of this question is beset with enormous difficulties. In the first place the parentage of many of the seedlings, excluding these from Demerara and Antigua, is unknown. Even in the Demerara and Antigua seedlings it is only the seed-bearing parent that is known. The pollen-bearing parent may be the same or may not be (except when the arrow is bagged before it is fertilized), even in the case of artificial polination by bagging two arrows together, because in this way the ovary may be cross-fertilized or self-fertilized. Attempts to emasculate the flowers before fertilization so as to ensure the parentage have been made by Messrs. Lewton-Brain and Stockdale in Barbados, but the method is extremely difficult and only a few seedlings have been obtained, thus far, so that accurate knowledge about both the parents is always doubtfully obtainable. Under these circumstances, this question can only be answered by a very wide range of observations extending over several years. I have got here photographs* showing the progeny of Bourbon, D. 625, White Transparent, and also crosses between D. 625 and Red Ribbon, D 625 and D. 95, and D. 95 and Red Ribbon. Considering the intricacy of the question, and the difficulties in the way, it is evident that not even a tentative conclusion can be arrived at for the present. But do we not get some indications of it? Here are photographs* of ten seedlings from Bourbon. Practically all of them, except D. 4395, resemble the Bourbon eye bud very closely. In five of them the channel is present, in the other five the channel is absent. But they fulfil all the conditions required by the Bourbon type of eye bud. Similarly, here are four seedlings from D. 625, side by side with the original. They also show the same kind of eye bud. In the original D. 625, the channel is entirely absent. In the seedlings D. 118, D. 167 and D. 335 we see a tendency to form a channel, but in every case the channel is shallow and tapering, disappearing upwards. In all cases, the eye bud is typically triangular and does not extend beyond the ring.

I shall not pursue this further because, as I have said in the beginning, my object is not to lay before you any definite conclusions, but to ask you some questions which have puzzled me during my studies.

In conclusion I tender my sincere thanks to Dr. Francis Watts, Mr. H. A. Tempany and Professor Harrison for the facilities and help they have freely given me in these studies.

---

* Not reproduced. A plate showing the five types of eye bud will, however, be published with the *West Indian Bulletin*, later.—Ed., *W.I.B.*

SUGAR-CANE INSECTS IN TRINIDAD.

BY F. W. URICH,
Entomologist, Board of Agriculture, Trinidad.

The object of these notes is to mention briefly the principal cane pests and their status in Trinidad. By having these records at their disposal workers in Demerara and the West Indies will be able to compare the status of the insects of their localities. When a pest is more numerous in a place, the circumstances may be put down to causes other than conditions of cultivation and soil, and it is then that co-operation among workers would come in. By comparing notes, valuable means of control either natural or artificial may be brought out. The difficulties in applying direct remedies on cane plantations are too well known; they are almost impossible when the canes are full-grown, and very expensive when they are young, so that we must always be on the look-out for natural enemies. I would therefore suggest that it is desirable that co-operative investigations in Demerara and the West Indies should be carried out with a view of ascertaining not only the biology of the pests but principally the status of their natural enemies.

BORERS IN THE STALK AND ROOT STOCKS.

CASTNIA LICUS. The caterpillar of this moth is a serious pest, and although not quite so prevalent as in Demerara it is capable of serious injury here. There is hardly an estate entirely free from it and some have been severely infested. The moths when not specially hunted are rarely seen about the cane fields, but when the reaping season comes on the numerous holes in the canes show the damage that has been done. It may be supposed that many caterpillars remain in the stalk of the cane and are destroyed in the mill, but unfortunately such is not the case, as they appear to remain in the root stock, tunnelling up the stalk for purposes of feeding. Generation is continuous and it is possible to find all stages of the moth at the same time. The only control that has been tried here is the catching of the adults. The following numbers have been caught on one estate in a period of three years:—

	1909.	1910.	1911.
January	12,055	6,534	7,808
February	15,272	5,128	12,942
March	4,812	1,537	2,517
April	10,231	1,730	4,337
May	13,185	5,730	4,836
June	31,989	7,579	7,364
July	29,164	18,936	4,114
August	14,701	14,449	14,556
September	15,197	13,022	18,567
October	17,096	12,306	5,086
November	12,356	13,162	2,405
December	8,676	16,594	5,236
Totals	182,734	116,707	89,768

About 60 per cent. of the total number caught are males.

DIATRAEA SPP. Diatraea is one of the longest known of the cane pests; three species of it occur on cane as well as on certain grasses about the cane fields, namely *D. saccharalis*, *D. canella* and *D. lineolata*. The damage done by these borers is generally underrated. As this pest is common in all the cane-growing islands and in Demerara, I would suggest a co-operative investigation in order to ascertain the status of Diatraea in each place, and so to obtain a complete knowledge of its biology. Conditions vary in each place, and it may thus be easier to ascertain facts in connexion with the life-history of these moths. I may cite an example. In his paper published in 1900, Mr. Maxwell-Lefroy mentions that the collection of egg masses in Barbados proved very successful, and also enabled him to find out the degree of parasitism in connexion with the eggs. In Trinidad it is not at all easy to find egg masses in the fields even when the canes are young. The same holds good of a plantation in Mexico where a careful search among young canes only yielded two egg masses. Is it not possible that the eggs are laid on grass when the canes are very young and that after a time the caterpillars migrate to the young canes? When the canes are tall and thick it is of course almost impossible to find egg masses on them. The only control employed in Trinidad for moth borers is the cutting out of dead hearts, but I think that the time has now come when we should co-operate to adopt some natural means of control and bring about an exchange of parasites.

RHYNCHOPHORUS PALMARUM. This pest, known since the time of the Rev. L. Guilding, cannot be said to be of much importance here. It mostly confines its attack to seed cane that has not been properly treated with Bordeaux mixture. Severe attacks are sporadic and rare, although isolated cases occur on almost every estate. The larvae often perish from want of food when occurring in a small plant. Ratoons are rarely attacked, and this only when from some cause or other fermentation sets in.

METAMASIUS HEMIPTERUS. This beetle is fairly common, but appears to be a pest of secondary nature. It will breed in cane that is fermenting. I have never seen it attacking a healthy plant. It is often found in pieces of cane left lying about the mill yard, or in spots where plant canes were cut; it also follows attacks of *Castnia licus* or *Rhynchophorus palmarum*, laying its eggs wherever the rind of the cane is broken or cut and when it is fermenting. *Metamasius sericeus* occurs in Mexico under much the same conditions as it does here.

XYLEBORUS PERFORANS is found only in canes fermenting from fungus attacks or any other cause.

ASPIDIOTUS SP. A species of Aspidiotus occurs on the stalk low down near the ground. It is not numerous, and the few specimens collected were affected by a parasitical Hymenopteron.

INSECTS AFFECTING THE ROOTS.

CERCOPIDAE, OR FROGHOPPERS. These insects have proved of late years to be the most injurious among pests. They have been occurring for many years past, but it is only of late that

they have been recognized as the cause of the so called cane blight. They have been the subject of extended investigations. The species doing the damage in Trinidad is *Tomaspis varia*, which appears to be indigenous to the island. There are records of froghoppers doing damage in other countries, but each place seems to have different species and it is peculiar that all are observed to live on grass and the sugar-cane equally well. In Mexico the injurious species is *Tomaspis postica*, which also occurs in British Honduras; in Panama it is *Tomaspis lepidior*; in Demerara, an apparently undescribed species of Tomaspis occurs, but from all accounts is not numerous enough to be injurious. Contrary to the habits of some members of the Homoptera, *T. varia* inserts its eggs by means of the ovipositor into the tissue of withering cane or grass sheaths, instead of choosing green and growing tissue. The eggs are deposited singly and take, in favourable weather, from twelve to twenty days to hatch.

In very dry weather, the eggs do not hatch immediately, and this appears to be the only resting or aestivating stage of the insect. The young nymph makes its way to the ground, attaches itself to the nearest cane or grass root, and surrounds itself with the spittle characteristic of the Cercopids. The nymphal stages last from thirty-two to forty-two days and during this time skins are shed four times, the cast skins remaining in the spittle mass. The proportion of males and females in the fields varies according to season, but, on an average, 51 per cent. of the total number are males. Each female is capable of laying thirty to fifty eggs. The nymphal stages are so well protected that no natural enemy appears to attack them. No parasites of the eggs have been observed. Adults are preyed upon by spiders. Birds do not seem to care for adult froghoppers. In Mexico a Reduviid bug, *Castolus plagiaticollis*, occurs in numbers and is very partial to the adult stages and I am now trying to introduce it here Eggs were sent from Mexico in September and October last year and the females obtained from this lot of eggs are now ovipositing. The adult stages are attacked by a fungus identified as *Metarrhizium anisopliae*. Experiments conducted with it have shown that, under favourable weather conditions, the froghoppers can be infected artificially. The other means of control recommended have been the burning of fields and traces after the canes are reaped, to destroy eggs; clean cultivation to avoid grass, and drainage of ground likely to remain too damp.

INSECTS AFFECTING THE LEAVES.

STENOCRANUS [DELPHAX] SACCHARIVORA. Although always present in cane fields, this insect rarely does any damage. On one occasion it increased to large numbers in an isolation cage, but when the attack appeared to be at its height most of the insects succumbed to an entomogenous fungus and were rapidly reduced. Besides, I obtained several cocoons and bred a species of a Dryinid (a hymenopterous parasite of Fulgorids). In the open fields the insects are not numerous and appear to be well kept in check by natural enemies.

CATERPILLARS. There are quite a number of caterpillars which feed on cane leaves; but with one exception, none have

ever been known to do any damage. All are kept in check by predatory and parasitic enemies. The species occurring are: *Caligo saltus*, several species of Hesperids, *Cirphis humidicola* and *Remigia repanda*. The last named is one that every now and then increases in numbers when for some reason the natural enemies fail to do their duty. In 1901 large numbers of these caterpillars suddenly appeared, in widely separated districts in the island, and devastated Para and Guinea grass fields. Since then they have not been observed in such large numbers, but in July 1909, 40 acres of canes on an estate in the Couva district were damaged by one brood. A second brood did not occur. The scale insects observed here are *Pseudococcus calceolariae* and *P. sacchari*, and a species of Pulvinaria; but the damage they do is not considerable as they are not very numerous, and are often controlled by natural enemies; this is especially the case with the last-named species.

GRASSHOPPERS. Occasionallly, the leaves are eaten by *Neoconocephalus guttatus*, but it does not occur in sufficient numbers to be injurious. It is generally found in the unfolding leaves of the cane during the day. The adults appear to be controlled by birds, and the eggs are often parasitized by a small Hymenopteron.

A QUICK METHOD FOR ESTIMATING MOISTURE IN MEGASS.

BY A. URICH. Ph.D. F.I.C.,

Analytical and Technical Chemist to the Trinidad Estates Company, Limited.

The methods in use for estimating moisture in megass require prolonged heating for several hours, until constant weight of the dry substance is attained.

A very rapid method for estimating volumetrically the water content appears not to be known sufficiently. I refer to the process of distilling off the water in the presence of petroleum and collecting the distillate in a graduated glass tube as proposed by Marcusson, Aschman and Ahrend*. Schwalbe and others. Originally devised by T. F. Hoffman for the estimation of moisture in grain and by Schwalbe in cellulose, W. Thorner showed that the process was applicable to a great many articles in the food and drug line, fertilizers, etc. He replaced xylol or toluol by petroleum (kerosene oil).

In *Zeitschrift für Angewandte Chemie*, 1908, he gives a long list of analytical results obtained, which in many cases agree remarkably well with those afforded by the usual drying process in an oven, the advantage being that an analysis could be made in about twenty-five minutes.

* *Analyst*, 1907.

By replacing Thorner's apparatus, which is a modified fractional distilling flask, by a short-necked, wide-mouthed flask, provided with a double perforated india-rubber cork, I found it to be well suited for megass, where strict accuracy is not required, respectively impossible on account of the difficulty of procuring a uniform disintegrated sample without the loss of some, even a considerable amount of moisture.†

As sugar is partly decomposed at the high temperature of about 350° F. attained for a short time towards the end of the distillation, and whereby too high results for water content are found, it was necessary to establish to what an extent the presence of sugar will interfere with the results of the analysis.

For this purpose, some air-dry megass which contained only traces of sugar, having been extracted with hot water, was thoroughly disintegrated, and for each experiment 12·5 grams were moistened with 12·5 c.c. of water and then distilled with 100 c.c. of petroleum. In three distillations the following amounts of water were collected (after making allowance for the water retained by the air-dry megass, estimated previously by drying to constant weight): 12·7 c.c., 12·5 c.c., 12·7 c.c.

If, after the end of the distillation, some more petroleum was added to the same flask and the distillation restarted, the distillate obtained was turbid through traces of water, which were, however, too small to be measured in the graduated tube. This showed that no water was formed by decomposition of the fibre, although a temperature of 360°F. had been reached when the distillation was interrupted.

Now, in the same flask, 10 grams of dry sugar was added and the distillation restarted with more petroleum. Water to the amount of 0·3 c.c. was collected, corresponding to 1·2 per cent. in the sample under examination. The continued distillation (with some more petroleum) gave 0·5 c.c. more water, showing the gradual decomposition of the sucrose. In these latter experiments an excess of sugar was present, such as is never found in genuine megass.

The analysis of a megass, obtained in a laboratory mill, and containing 7 per cent. of sucrose, gave :—

	a.	b.
By distillation ...	65·6 per cent.	65·8 per cent., of moisture
By drying in the stove	65·4	„

Another sample gave :—

By distilling ...	65·9 per cent. of moisture	
By drying	65·2 „	„

With sliced sugar-cane the difference between the two methods was higher, amounting to 1 per cent

Found by distillation	75·4 per cent. of moisture.	
„ drying ...	74·6	..
In another sample :—		
Found by distillation	74·8 „	„
Found by drying ...	73·8 „	„

† When using a meat-chopping machine, as recommended in Hawaii, an allowance of 4 per cent. for loss through evaporation is made.

I use the distilling method only for megass in conjunction with the estimation of sucrose by means of the 'beaker' or rather 'pot' method.

Whether the method will suffice for sugar-cane or for the estimation of fibre, the analyst must decide for himself by some comparative tests. Very likely, the discrepancy between distillation and drying in the stove will be a constant one, and therefore the results admissible.

The quick method, after a little practice, is very easy and safe, occupying about three quarters of an hour—actually twenty-five minutes for the distillation. The petroleum used is the kerosene oil imported in Trinidad, of 105° F. flash point. I use a flask with a short, wide neck (diameter of neck 1¼ inch) of 300 c.c. capacity, charged with 25 grams of megass and 100. c.c. of petroleum. The flask is surrounded, once for all, with a well-fitting brass wire wove. Thus protected, it will serve for a hundred and more distillations. It is mounted on a tall retort stand which is placed on a small box, 10 inches high, thus to allow of a distance of almost 3 feet from the base of the table. This height is necessary on account of the 50 c.c. measuring tube (graduated to $\frac{1}{10}$-c.c.) and of the long discharge pipe for the distillate. The flask is provided with a double perforated india-rubber cork, one hole to receive a thermometer with a legible paper scale and the other for the rather narrow ($\frac{1}{16}$-inch lumen) glass tubing for the distillate. One leg of this tube is very short (2½ inches) in order to avoid premature condensation, but the other one, bent downwards at an inclined angle, is about 15 inches long, in order to discharge the condensed water and petroleum into the lower part of the graduated tube. This tube is inserted and held in a vertical position in a somewhat large glass cylinder holding about 2 litres of water, the large bulk of which admits of dispensing with a Liebig's condenser. The cylinder is placed on some blocks of wood, and is only lowered gradually to the level of the table when the distillate threatens to close the end of the delivery tube.

The distillation progresses rapidly, and without any bumping, the thermometer indicating a temperature of about 220 °F. for the vapours. Only towards the end of the distillation the temperature rises suddenly and soon reaches 330° to 360 °F. At the same time white fumes are formed, and the distillation must be stopped by removing the lamp. By lifting the thermometer, which must move with gentle friction in the cork, having been coated with vaseline previous to starting the distillation, the re-entering of any liquid from the longer leg of the tubing into the flask is prevented. The measuring tube contains now, say, 13·8 c.c. of water and about 30 to 35 c.c. of petroleum, the latter holding in suspension about 0·1 c.c. more water, which will separate only after several hours. (This amount is fairly constant, if the work is always done under the same conditions. Any small drops of water adhering to the walls of the measuring tube are brushed down by means of a small feather fixed in a long glass tube.)

Suppose 25 grams of megass has been taken and 13·9 c.c. of water obtained, the megass will contain 55·6 per cent. of moisture,

or to be more exact, 55·4 per cent., as 13·9 c.c. of water at, say, 86 °F., weighs only 13·85 grams.

For a second analysis, the flask need not be wiped dry, but only emptied of the megass by means of a hooked copper wire. In case more than two or three distillations have to be made in quick succession, it is advisable to have a spare india-rubber cork with tubing, as the cork is apt to swell temporarily by prolonged action of the petroleum vapour. Ordinary corks are not subject to this drawback, but they get hard after some time and make the whole apparatus more rigid.

The greatest drawback of the quick method is the smallness of the sample operated on. With only 25 grams of megass, a difference of 0·1 c.c. of water collected in the measuring tube means 0·4 per cent. of moisture. I tried to work on a larger scale, viz. with 50 grams of megass and 200 c.c. of petroleum, but it took too long a time to obtain the temperature required, with the spirit lamps at my disposal. For this experiment I had enlarged the capacity of the 50 c.c. measuring tube by joining it to the neck of a small flask, the bottom of which had been cut off, as not only, say, 28 c.c. of water, but also from 60 to 70 c.c. of petroleum had to be collected. To work with 100 grams of the bulky material was out of the question.

The most reliable method is to work with 500 grams, or more, of megass, as recommended by Watts and also by Heriot. The preliminary drying is done in a shallow tin box placed on the top of a steam boiler, followed by a final drying in a capacious stove—a process occupying, however, a whole day; an additional inconvenience arises from the smell of the pitch oil stove that has to be used for many hours in a confined tropical sugar laboratory.

THE SUGAR INDUSTRY IN ANTIGUA AND ST. KITTS-NEVIS.

BY H. A. TEMPANY, B.Sc. and F. R. SHEPHERD.

In the *West Indian Bulletin*, Vol. VI, p. 373, an account was given of the Sugar Industry of Antigua and St. Kitts between the years 1881 and 1905.

The following additional information is given regarding the progress of the industry in these two Presidencies of the Leeward Islands Colony, thus bringing the account up to date.

ANTIGUA.

In Antigua the period 1905-11 may be looked on as one of considerable development in the cane sugar industry. This development may be said to have commenced in the year 1903, when the abolition of the sugar bounties by the Brussels

Convention served to impart stability to the industry, and led to the erection of two well-equipped modern central sugar factories, and the introduction of other improvements in cultivation and manufacture

Since these earlier days, the progress thus begun has been continuous and considerable.

The central factory system inaugurated in this way has continued to expand and to extend its operations over large areas, to the supersession of the muscovado process.

Considerable additions have from time to time been made to the plant of the Gunthorpes Factory, and in 1910 the capacity of the factory was very largely increased in order to allow of the inclusion of a number of additional estates in the scheme.

Between the two factories, it is estimated that a total output of between 9,000 and 10,000 tons of grey crystal sugar represents their maximum capacity at the present time.

The exports of sugar for each year from 1905 to 1911 have been as follows:—

Year.		Tons.
1906	...	10,006
1907	...	13,950
1908	...	12,511
1909	...	8,671
1910	...	13,514

The average return for the entire period is 11,622 tons.

This amount considerably exceeds that of the period 1895 to 1904, when the average annual production amounted to 10,209 tons, but falls considerably short of that of the period preceding this, namely 1881 to 1894, when the average annual export amounted to 13,113 tons.

It is not too much to say, however, that the increased productions of the past six years as compared with that in the preceding ten is due almost entirely to the introduction of improved methods of manufacture.

The severe economies necessitated by the series of disastrous years 1895 to 1903 have left their mark in the shape of impoverished soils, from which a slow recovery is now taking place. In addition a continued series of seasons of indifferent and badly distributed rainfall, combined with the increased ravages of root disease (*Marasmius sacchari*) has served to reduce the yields.

The belief may, however, be expressed that the advent of more propitious seasonal conditions, combined with a liberal and enlightened agricultural policy tending towards increased fertility and reduction of diseases, will result in increased yields in the future.

A noteworthy point in connexion with the sugar industry of Antigua is the impetus that the establishment of the central factories has given to cane cultivation by peasant growers ; under the terms of the contract by which grants in aid of the construction of Gunthorpes and Bendals Factories were made, peasant canes up to a limited amount must be purchased if tendered at

prices fixed fortnightly by the Government in accordance with the market price of sugar.

The effect of this has been greatly to stimulate peasant cane production, and each year considerable quantities of cane are purchased in this way.

The actual amounts of sugar-cane bought each year since 1906 are given below:—

Year.		Tons.
1906	...	6,539
1907	...	10,249
1908	...	6,766
1909	...	4,580
1910	...	7,719

The area under cane cultivation in Antigua has not varied to any appreciable extent during the past twenty years; in 1909 the total area amounted to 16,179 acres, and it has remained constantly in the region of this figure for the past thirty years.

Considerable areas of land capable of being included in sugar-cane cultivation exist; and if further extensions in the central factory system take place, there would appear to be every likelihood of the area under cane being enlarged.

The past eight years owe their importance to the fact that during this period the applicability of the central factory system to the conditions obtaining in the Leeward Islands has been abundantly demonstrated. The effect of this has already been seen in the considerable extensions of the system which have taken place in Antigua, and the similar developments now in progress in St. Kitts. With continued success further extensions may be anticipated.

St. Kitts-Nevis.

The exports of sugar from St. Kitts-Nevis from 1906 to 1910 have been as follows:—

Year.		Tons.
1906	...	15,196
1907	...	14,178
1908	...	11,044
1909	...	12,927
1910	...	12,510

When these figures are compared with those for the previous years, we find that in 1906 the exports of sugar were 5,196 tons, which was about 20 per cent. increase on the average exports for the previous ten years.

In 1907, the area under cane was reduced chiefly in Nevis by some 1,500 acres, but the crop in 1907 was still above the average.

Taking the average crop of the Presidency for the past five years, which is 12,990 tons, it will be seen that, although, the acreage under cane has been reduced within this short period by 1,500 acres, yet the average of the exports of sugar is just

about the same as the previous ten years, which was 12,884 tons. This seems to indicate that the returns given by the more newly introduced varieties are greater than those obtained from the old Caledonian Queen variety formerly grown.

It must further be remembered that in the past five years an intermediate crop of cotton has been planted on many of the estates in St. Kitts; this would tend naturally to cause some slight reduction in the return per acre from those lands where owing to late ripening of the cotton, the young plant crop cannot be got in at the right time.

The existing area under cane cultivation in St. Kitts amounts to approximately 7,200 acres, while that in Nevis is approximately 1,500 acres.

The returns of sugar per acre from the cane-growing areas of St. Kitts are considerably larger than those in Nevis—a result partly due to the better rainfall and the readily workable and fertile soils of the former island.

During the past year negotiations were completed for the erection near Basseterre, St. Kitts, of a central sugar factory. This is now nearing completion and will be ready in time to deal with the sugar crop to be reaped in the early part of 1912. The factory will be capable of a maximum output of 10,000 tons of grey crystal sugar. During the first two years of its existence it is not contemplated that it should work to its full capacity, but it is hoped that it will embrace eventually about half the sugar-growing lands of the island.

This innovation constitutes an event of the first importance in the history of the island, and marks the inauguration of the supersession of the muscovado industry.

The firm of Henckell du Buisson & Co., of the Gunthorpes Factory, Antigua, is also responsible for the promotion and erection of the St. Kitts Factory, and the hope may be expressed that acceptable plans may be formulated soon for the introduction of the central factory system into those portions of the St. Kitts sugar-growing areas at present unprovided for in this way.

In St. Kitts, but little if any peasant cane is grown, almost all the available sugar land being occupied by estate cultivation. In Nevis, sugar-growing by peasants is practised on a somewhat larger scale. Arrangements exist whereby certain of the sugar estates purchase canes from peasants at rates periodically fixed by the Government, and based on the current market price o sugar.

On the whole, the sugar-growing industry of St. Kitts may at the present time be said to be in a satisfactory condition, and its present prospects are for considerable further advances in the future. The fact that of recent years St. Kitts has not shown the falling off in production evinced in the case of Antigua is attributable to the occurrence of more favourable seasonal conditions, combined with the remarkable character of the St. Kitts soils which are at once deep, fertile and easy to work. These factors have combined to render the maintenance of fertility in times of stress an easier matter than is the case in the

sister island, where the heavy character of the soil renders all cultural operations more costly.

The following tables form a continuation of those given in the *West Indian Bulletin*, Vol. VI, p. 382, and record the total productiveness of the sugar industry in both Presidencies during the period under review :—

EXPORTS OF SUGAR AND MOLASSES FROM ANTIGUA, 1906-11.

Year.	Tons of sugar.	Value of sugar.	Puncheons of molasses.	Value of molasses.	Acreage of land in sugar-cane.	Value of one ton of sugar.
		£				£
1906	10,006	71,967	4,424	10,184	15,831	71·9
1907	13,950	124,425	7,282	21,242	14,935	8·9
1908	12,511	135,168	5,784	21,830	15,977	10·8
1909	8,671	82,595	4,125	20,109	16,179	9·5
1910	13,514	160,929	6,155	23,081	16,090	11·9
1911	11,079	...	5,374	...	...	...

EXPORTS OF SUGAR, MOLASSES AND RUM FROM ST. KITTS-NEVIS 1906-10.

Year.	Tons of sugar.	Value of sugar.	Puncheons of molasses.	Value of molasses.	Acreage of land in sugar-cane.	Value of one ton of sugar.	Gallons of rum.	Value of rum.
		£		£		£		£
1906	15,191	104,843	3,017	7,548	17,066	6·8	31,777	1,568
1907	14,178	118,101	2,154	6,465	15,678	8·2	44,460	2,254
1908	11,044	102,497	2,745	9,607	15,539	9·2	33,942	2,400
1909	12,027	108,450	3,192	11,970	15,536	8·3	27,175	1,976
1910	12,510	138,273	2,682	8,047	15,536	11·0	18,934	1,793

[Pages 275 to 398, issued July 10, 1912.]

WEST INDIAN AGRICULTURAL CONFERENCE, 1912.

(CONTINUED.)

PLANT DISEASES AND PESTS, COCOA-NUT, LIME AND FRUIT, AND RICE INDUSTRIES.

THE USE OF ENTOMOGENOUS FUNGI ON SCALE INSECTS IN BARBADOS.

BY J. R. BOVELL, I.S.O., F.L.S., F.C.S.,

Superintendent of Agriculture, Barbados.

Within recent years it has been found in some of the West Indian islands and in Florida that certain fungi are parasitic on Lecanium and other scales attacking economic plants and trees. In the *Bulletin of Miscellaneous Information* of the Botanical Department in Trinidad for January 1902, the late Mr. J. H. Hart, F.L.S., then Superintendent of the Botanical Department in Trinidad, who was a keen observer, mentioned that for the past few seasons he had noticed that various limes, oranges, lemons and other species of citrus fruits had been at certain seasons covered with a fungus and that a close examination showed this to be parasitic on the *Mytilaspis citricola*. He goes on to mention that the same subject had been recently discussed in an American publication, and that on writing to the author,

Professor P. H. Rolfs, he had been favoured with specimens of the American parasite, and on comparing this parasite with that occurring in Trinidad, it was seen at once that they were identical. The name attached to the fungus by Professor Rolfs was *Sphaerostilbe coccophila*. In April of the same year, Mr. Hart mentioned that he had just received from a correspondent another fungus, *Ophionectria coccicola*, of which it was said that it was sufficient to keep the long scale and purple scale in control, and so severe was it on the scales that it soon destroyed its own host and then died, so that none lived to attack the insects when reinfection took place.

In the same year, Mr. H. Maxwell-Lefroy, M.A., F.E.S., F.Z.S., at that time Entomologist of the Imperial Department of Agriculture, mentioned, in a paper entitled The Scale Insects of the West Indies, published in the *West Indian Bulletin*, Vol. III, pp. 240 and 295, that *Saissetia hemisphaerica* [Lecanium hemisphaericum] was being killed by a fungus which subsequently formed a matted white growth on and around the scale, and that it was more common in Grenada than in Barbados. From the description it is probable that Mr. Lefroy referred to what is now known to be *Cephalosporium lecanii*. Subsequently, fungi have been found attacking scales in Dominica, Montserrat and other West Indian islands.

Knowing that scales were being attacked by fungi in various countries, I had for some time been on the lookout for fungi attacking scales in Barbados, but it was only in August 1909 that I found the black scale, *Saissetia nigra* (Nietn.) [Lecanium nigrum] being killed by a fungus on a variety of Hibiscus at Mistletoe on the sea-coast in Christ Church. As this Hibiscus was growing as a hedge and was being trimmed by the caretaker, I obtained permission to take away some of the branches that were cut off, and these I attached to a number of mango, cherry and other trees at Dodds on which were, comparatively speaking, a large number of *Coccus viridis* (Green) [Lecanium viride], *Coccus* [Lecanium] *mangiferae* (Green), *Pulvinaria* [Protopulvinaria] *pyriformis* (Ckll.), *Vinsonia stellifera* (Westw.), and other scales. At that time, owing to the attacks of the scales, the leaves of the trees at Dodds were thickly covered with black blight, a fungus which, as is well known, grows on the excretions of the scales. In a short time it was found that the Coccus and *Pulvinaria pyriformis* scales were being killed by the fungus, and after a little while it was difficult to find scales that had not been attacked. As soon as it was ascertained that these scales could be effectually parasitized by attaching portions of plants containing scales infected by this fungus to trees on which similar scales were found, a number of small branches of the cherry and other trees at Dodds containing parasitized scales were distributed to various places, including Queen's Park, Coverley, Bulkeley, Stirling and Erdiston. At Queen's Park, where they were first attached, a large number of scales were in a short time parasitized by the fungus. The rainy season for 1910 came to an end just about the time of the infection at Queen's Park and the places mentioned above took place, and during the dry weather the attacks of the fungus seemed to have been checked and in some instances the fungus to have disappeared altogether. On the advent of the

rainy season, however, the fungus reappeared and spread rapidly, until at the time of writing (January 1912) it is almost impossible to find Coccus and Pulvinaria scales at Dodds not attacked by this fungus, while at Bulkeley, Coverley and the other places to which the branches with the parasitized scales had been distributed, numbers of the Coccus and other scales subject to attack by *Cephalosporium lecanii* have been killed.

In examining the various scales during the course of the experiments mentioned above, a fungus was found attacking the star scale, *Vinsonia stellifera* (Westw.), which on examination by Mr. F. W. South, B.A., the Mycologist of the Imperial Department of Agriculture, proved to be a specimen of Cladosporium. A fungus was also found on *Aspidiotus destructor*, on the leaves of the mango trees at Dodds. This scale has since been examined by Mr. W. Nowell, D.I.C., the Assistant Superintendent of Agriculture, who is of the opinion that the fungus is a species of Phoma or some genus nearly related.

It may be mentioned incidentally that at the same time a hymenopterous insect and a mite were found parasitizing *Vinsonia stellifera*, and a mite *Lepidosaphes beckii* (Newm.) [Mytilaspis citricola, Pack.]. It appeared, from what had already been done with regard to the use of entomogenous fungi in keeping in check certain of the scales, that it might be possible to very greatly reduce the injury done to the various economic trees and plants which are badly attacked in Barbados, if the spores of the various fungi could be easily and expeditiously distributed on the scales. Therefore, as soon as Mr. Nowell, who had a great deal of field experience in mycology, and who had specialized in mycology and entomology at the Royal College of Science, was appointed in September last, an attempt was made to cultivate and to spread these fungi by means of spraying the trees attacked, with spores suspended in water. Since Mr. Nowell has been carrying on this work, another fungus was noticed by Mr. M. S. Goodman, an officer of the Barbados Department of Agriculture, on a coffee plant in Queen's Park, growing on *Coccus viridis* [Lecanium viride]. This on examination was found to resemble the description of what is known as the Cinnamon fungus in Florida. Mr. Nowell, who examined the dead scales, reported that this fungus was the probable cause of death. Experiments were instituted to test this, when it was found that the infected *Coccus viridis* could be kept alive in hanging drops for several days, during which time the fungus gradually developed, producing its characteristic fruit before the scales died, the body of the insect becoming filled with hyphae and its margin fringed with conidiophores. On its being found that this fungus was parasitic on the *Coccus viridis*, the fungus was cultivated, and the spores suspended in water and sprayed on some of the trees and plants attacked by that pest. At the time this is written, at least 75 per cent. of the insects are dead and covered with the fruit of the fungus. Since a fungus similar to, or identical with this, is recorded as attacking white fly in Florida, a trial was made with a severe infestation on an Ipomoea. A few days later the fungus was found to be fruiting abundantly on a considerable number of larvae and pupae, but no definite proof has yet been obtained of the adult being killed by the fungus.

Some months ago I noticed on the leaves of an anonaceous plant from a district in the centre of the island the red-headed fungus, *Sphaerostilbe coccophila*, parasitizing what appeared to be *Lepidosaphes beckii* [Mytilaspis citricola]. The scales were so covered by the fungus as to be difficult to identify. Search was made in the neighbourhood and I found the fungus on *Selenaspidus* [Aspidiotus] *articulatus* (Morg.), on *Funtumia elastica* growing in a gully at Sion Hill plantation. Since then Mr. Nowell has also found this fungus in two orchards, in each case on *Chionaspis citri* on citrus trees. Although it is recorded as commonly attacking *Lepidosaphes beckii* [Mytilaspis citricola], and this species was abundant on the leaves of the same citrus trees, in this case no signs of infection were found. Experiments are now being carried on to ascertain whether it is not possible for it to be spread by artificial means.

Mr. Nowell has also found two fungi parasitizing *Orthezia praelonga* (Dougl.), one some weeks ago on a Barbados cherry hedge (*Malpighia glabra*) at Coverley, and the other quite recently on the same insect on the sea-side grape at Long Bay Castle. Knowing that the sea-side grape trees at Long Bay Castle were being badly attacked by the *Orthezia praelonga*, the fungus found at Coverley, which was very effective there, was cultivated and the badly infected trees at Long Bay Castle sprayed with the spores suspended in water, but up to the present time the infection has not been successful. It may be mentioned that since the insects were sprayed with the spores of the fungus the weather conditions—no rain and high dry winds—have been very unsuitable to the growth of the parasite. It is still hoped, however, that when more suitable weather conditions prevail, it may be found possible to infect these scales. In the meantime the fungus recently found is being cultivated so as to obtain a plentiful supply of spores for spraying these pests.

In addition to the fungus found last year on the star scale (*Vinsonia stellifera*) quite recently another fungus has been found by Mr. Nowell attacking this pest on citrus trees at Strong Hope in the parish of St. Thomas. This fungus, which envelopes the scale in a light red stroma and bears shortly fusiform conidia, is being cultivated for the purpose of ascertaining to what genus it belongs and for spreading it when the weather conditions are favourable.

From the brief account given above of the results obtained in Barbados with entomogenous fungi and from what has been done in Florida and other places, it is hoped that as soon as more is learnt of the habits of the fungi and the methods of cultivating and spreading them, it will be possible to keep most of the insect pests attacking economic and other plants and trees in Barbados in check.

FURTHER NOTES ON THE FUNGUS PARASITES OF SCALE INSECTS.

BY F. W. SOUTH, B. A.,

Mycologist to the Imperial Department of Agriculture.

In the following pages further information is given on the use of parasitic fungi as a means of controlling scale insects. The subject-matter consists largely of the results of observations conducted regularly in the Windward and Leeward Islands during the last eighteen months, and may be taken as a continuation of the paper on the same subject which appeared in the *West Indian Bulletin*, Vol. XI, p. 1. The fungi dealt with are the same four species as were previously described, namely the red-headed fungus (*Sphaerostilbe cocophila*, Tul.), the white-headed fungus (*Ophionectria cocicola*, E. and E.), the black fungus (*Myriangium Duriaei*, Mont.), and the shield scale fungus (*Cephalosporium lecanii*, Zimm.). In addition to these, some suspected new parasites have been found; one is the Aschersonia stage of a fungus identified at Kew as *Hypochrella oxyspora*, Massee, which from its systematic position is almost certainly a parasite, though no inoculation experiments have yet been carried out to prove it; another is the Hormodendron stage of an unidentified species of Cladosporium of which the parasitism is uncertain; while certain other species as yet not investigated have been observed on dead scale insects. One of these has a dark-green or nearly black superficial mycelium, light grey or nearly white at the margin, which spreads in patches often as much as 4 inches or more in diameter over the surface of the white scale (*Chionaspis citri*) on limes. It has been observed in Dominica and Antigua. In this connexion, it is interesting to note in passing that Tower records more than one black fungus preying upon the purple and white scales (*Lepidosaphes beckii* and *Chionaspis citri*) on Citrus trees in Porto Rico. Judging from his Fig. 1, *Myriangium Duriaei* may be one of these. (Insects Injurious to Citrus Trees and Methods for Combating Them. Bulletin 10, Porto Rico Agricultural Experiment Station.)

From an economic point of view, the chief importance of these fungi lies in their use as a control of scale insects on citrus trees, while the shield scale fungus is also of service as a parasite of the soft green scales such as *Coccus viridis* and *Coccus mangiferae*, which are especially associated with black blight. The red-headed fungus may also be of some service in this respect, and is very useful in some islands as destroying the akee fringed scale (*Asterolecanium pustulans*), which develops very freely on Castilloa.

EFFECTIVENESS OF THE FUNGI.

There appears to be some doubt as to the power of these parasites to supply an adequate control of their hosts, so that the following instances of their unaided effect may be of interest.

The red-headed fungus (*Sphaerostilbe coccophila*) was observed to be present on the white scale (*Chionaspis citri*) attack-

ing limes at the Botanic Station, Dominica, in July 1910; while it became increasingly prevalent during August. In September, no young insects were noticeable on the trees, while the fungus was very common. During October and November, the fungus disappeared, until only traces of it could be found on old scales. No further young scales appeared on the trees in those months. Parallel observations were supplied by Mr. J. C. Macintyre from Hampstead estate. Major Becher of Sherwood estate noted the presence of a considerable quantity of green scale (*Coccus viridis*), in August, which was parasitized by the shield scale fungus. The scale disappeared almost entirely in September, and none was seen in October and November. The observer thinks that this cannot be explained as a result of fungus attack alone, and notes the almost complete absence of all insect life during the months of September and October. On the other hand, he also records the prevalence of the fungi during those months, the white-headed, red-headed and black species being common on the purple scale, which was almost exterminated. At the Agricultural School in the same island, the shield scale fungus was found in July on the green scale (*Coccus viridis*) on limes; by November the insects had entirely disappeared from the tree. Similar observations are recorded from Harris's Experiment Station, Montserrat. There, the shield scale fungus appeared on the green scale on coffee, in July, and had entirely destroyed it by October; in another instance, exactly the same thing happened in the case of the brown shield scale (*Saissetia hemisphaerica*) on *Eranthemum* sp.; yet again the same fungus attacked the green scale on navel orange trees in October, and had completely destroyed it at the end of November.

In a damp district in St. Lucia, it was found that every individual of a species of Aspidiotus on limes was attacked by the red-headed fungus, in October, while the scales only occurred in the proportion of one to each leaf. It was also reported that the scale insects on the rubber trees at the Agricultural School which were numerous, though vigorously parasitized in February (see *West Indian Bulletin*, Vol. XI, p. 19), were almost completely removed by the red-headed fungus by October. These observations all apply to the year 1910, but many of them could be duplicated from the records for 1911. Several other instances of exactly the same nature are on record at this Office, though space does not permit of their enumeration here.

The fungi are most certainly more useful in Dominica and St. Lucia—islands with a high rainfall—than in Montserrat and Antigua where the rainfall is lower. In the two former they appear to exercise an efficient natural control in normal seasons, without any artificial aid. In the latter they would require considerable assistance to enable them to produce an equal effect. In Grenada their propagation is being conducted systematically, and there are signs that useful results are being arrived at. The conditions in this island are suitable, but for some unknown reason the natural distribution of the fungi appears to have been limited; possibly this is due to the fact that cacao is the principal crop and it is not attacked by scale insects. On the other hand, black blight was a serious nuisance in Grenada, particularly on

large isolated mango trees. It is possible that the shield scale fungus, which controls the mango shield scale (*Coccus mangiferae*), and therefore the attendant black blight, is not easily spread from tree to tree by natural means, though artificial inoculations are meeting with some measure of success. The reason for suggesting this will be given below. In St. Vincent, where again the conditions are very suitable, the fungi are not as serviceable in destroying citrus scales, as it might be expected that they would be. The growth of citrus plants in that island is almost entirely prevented by scale insects, and the fungi, again, for some unexplained reason, do not show signs of rapid increase. In St. Kitts, Nevis and the Virgin Islands these parasites have not received much attention, as there is but little Citrus grown, and black blight is not much in evidence.

PERIODICITY.

It was thought that continuous observations would reveal some seasonal periodicity in the appearance of fructifications of the various fungi. To a certain extent, the records, which have been continuous for two years, have confirmed this, but such periodicity is not very strongly marked Fructifications of, at any rate, the red-headed, black, and shield scale fungi may be found at all seasons of the year; though they are much more numerous and more generally prevalent from the middle to the end of the rainy season, that is from September to December than in other months.

The records show that under favourable circumstances the fungus can kill all the scales on a tree in about three months. At the end of that time, no young are to be found and the fungus occurs on a few old scales only; finally both disappear and the tree remains healthy until a fresh infection of scale insects occurs. In some cases the fungus fails to destroy all the young, and the tree is again attacked by individuals produced from those causing the original attack. In such instances, however, the fungus which is still present on the old scales quickly infects the developing young and checks their spread. The following observations illustrate this. The shield scale fungus occurred on the green scale on Citrus, in Dominica, during July and August 1910, and the number of young was few. In September no young were found, but a few were present in October. The fungus was not observed in September or October. In November, the young present were still few in number and the fungus had re appeared.

THE EFFECT OF BENGAL BEANS AND COVER CROPS.

The evidence shows, as is stated in the former paper, that Bengal beans have a beneficial effect in ridding lime trees of scale insects, but recent observations do not support the theory that their effect is entirely produced by the encouragement that they give to fungus parasites. The following experiment to test this point was conducted in Montserrat. Two plots were laid out, one in which the beans were planted between the limes, the other in which they were allowed to grow over the trees. The adjacent portions of the field not planted in beans served as a control. In October it was observed that the perithecial stage

of the red-headed fungus was equally common on both plots and also on the field where no beans were grown. On the other hand, it was noticed that the young scale insects on the trees covered in beans were sickly, and many were dead; although no definite parasite could be found on them. Thus, though the beans have an undoubtedly beneficial effect, this does not appear to be mainly due to encouragement of the fungi. Further experience goes to show that the beans should certainly be used with care, as too heavy a covering harms the trees; moreover, there seems to be an opinion in Dominica that this method of treatment is not suitable in that island, though no results of definite experiments are available.

One factor which may be responsible for part of the effect of the beans is suggested by a paper in the *Journal of Agricultural Science*, Vol. III, p. 297, by Professor J. G. Lipman, which describes an experiment to illustrate the benefit derived by non-leguminous crops from growing them in mixtures with legumes. The experiment showed that the non-leguminous crop was able to benefit directly from the nitrogenous substance which diffused out of the roots or bacterial nodules of the legume.

Although the experiment in Montserrat, supported as it is by general field observations, indicates that the covering of Bengal beans has little direct beneficial effect on the fungus parasites, yet it is worthy of record that the officers of the Agricultural Experiment Station in Florida believe that a soil cover, whether of legumes or of grass, is distinctly advantageous for two reasons. While it is growing, the water transpired from the leaves increases the moisture content of the air around the trees and thus aids the fungi; when it is cut, it forms a good surface mulch which also prevents undue loss of water. It may be noted that deep stirring of the soil, once it has been fully permeated by the tree roots, is not generally practised in Florida; usually, the cover crop is either harrowed in after it has been cut, or allowed to lie on the surface and decay. It should, however, be understood that the growth of a properly regulated cover crop is not to be confused with permitting the estate to become overgrown with bush.

Artificial Encouragement of the Fungi.

In Florida, in very favourable years, it is found that the natural rate of spread of the fungi is sufficiently rapid to enable them to control the scale insects and white fly; the same thing is probably true of Dominica and St. Lucia, and possibly of other islands. In general, however, the natural means by which the spores of these plants are conveyed from tree to tree are not sufficiently rapid in their action to ensure a thorough distribution of the parasites, such as will account for their presence on practically every individual of their hosts—a condition of things often attained in Florida. Another point which indicates the advisability of employing artificial means of encouraging their spread is that in the case of Cephalosporium, in particular, the spores are held together by a thick mucilage which is soluble in water, but is apparently persistent in dry conditions. This must hinder the distribution of the spores by wind; probably rain and

insects are the more common agents. Mr. W. H. Patterson, Master-in-Charge of the Agricultural School, St. Vincent, called the writer's attention to two trees growing in the school grounds, at a distance of only a few feet apart, one being to windward of the other. The scale insects on the tree to windward were attacked by the shield scale fungus, but those on the tree to leeward were not, so that it would seem that infection is not easily spread by wind. In the case of large, isolated mango trees also, artificial infection is practically essential. In such cases, if infected material is used for spreading the Cephalosporium, it should be tied into the top of the tree if possible, so that the spores can be washed down by rain; while care should be taken to bring infected leaves into contact with the under sides of the leaves to be infected, as the scales are most numerous on that side. The fact that the under side of the leaves is that upon which the infecting spores should alight may render spraying the best method of inoculation. Mr. A. J. Brooks, Assistant Agricultural Superintendent, St. Lucia, has informed the writer that the tying-in method of inoculation gives satisfactory results, provided the inoculated trees are sprayed with clean water morning and evening, during the first week after the inoculations have been made. The spraying should be made at intervals of a few days, in dry weather.

In Florida, the conditions are somewhat different from those in the West Indies, as the country is flat, and citrus cultivations often occupy a considerable area without interruption; moreover, artificial inoculations have been carried on so persistently and upon such a large scale that spores of the parasitic fungi abound, and with the artificial encouragement that these organisms receive, they are able to infect practically every scale on a tree, in many instances. In the West Indies, the areas planted in citrus are usually circumscribed in extent, either by belts of forest or by foothills or other irregularities of the ground. Little artificial assistance is given to the fungi, so that although they occur on insects attacking bush and forest plants, their spores are not nearly so numerous, and except in Dominica and St. Lucia their effect is limited. In most of the islands it is necessary that persistent organized efforts should be made to ensure artificial spread of the parasites, if this means of controlling scale insects is to be successful from an economic view point. Very little effect beyond that already observed can be expected if the fuugi are merely left to themselves. It would be advisable to conduct inoculation work at the commencement of the wet season, as it is from that time onward until its close that the spread of the fungi is most vigorous. The inoculations should be repeated more than once in each year and continued annually. By this means only can really satisfactory results be expected in the majority of the islands, for this is the only way of maintaining the fungi in sufficient numbers to cause an epidemic among the scale insects every year.

Inoculation experiments in Grenada and Barbados have met with some measure of success. In Grenada, material infected with the shield scale fungus was sent with a circular letter to several planters by the Superintendent of Agriculture requesting them to tie it into trees affected with black blight following the

mango shield scale (*Coccus mangiferae*). Other steps were taken to spread the same fungus on the soft green scales, with the result that a marked improvement as regards mango trees has been observed. In Barbados, the Superintendent of Agriculture introduced the same fungus into the Botanic Station at Dodds early in November 1910. The method employed was to tie infected material into the trees. The scales thus parasitized were the mango shield scale on mango, and the common green scale (*Coccus viridis*) on guava, and Barbados cherry. In December, very few scales remained which had not been attacked by the fungus.

In St. Kitts, experiments aiming at the introduction of the white-headed fungus have not been so successful as was anticipated; though it is desirable that they should be repeated, as some of the fungi occur there naturally and the conditions appear to be moderately suitable. In St. Vincent, inoculation experiments with the shield scale and red-headed fungi, conducted by the spraying method, have also been disappointing in their results; though more effect may have been produced than was believed at the time when the observations were reported. It is possible that insufficient attention was paid to the condition of the material used for inoculation and to the season of the year, both in St. Kitts and in St. Vincent. In any case, the experiments should be repeated. Much further inoculation work of all kinds remains to be done, as there is little doubt that, at present, no approach to the full effect of these useful plants is obtained in the West Indies, mainly because so few systematic attempts have been made to encourage their spread.

Considerations Regarding the Use of Insecticide Spraying Solutions.

Experience in Florida has led to a greater reliance from year to year on the natural means of controlling scale insects, though this is still assisted by discriminate spraying with solutions not harmful to the fungi and by fumigation whenever the natural enemies appear to be inadequate. Fumigation is not generally suitable to lime cultivations in the West Indies, on account of the relatively small value of the trees and of the difficulties due to the nature of the ground. Spraying is conducted systematically on certain estates in Dominica, the solutions used being made of rosin compounds and whale-oil soap mixtures. These are harmless to the fungi, and their discriminate employment may be necessary at times. More particularly is this the case when an epidemic attack of scale insects occurs, as not only would the use of such solutions reduce the immediate damage inflicted, but it would also enable the fungi to regain more quickly the supremacy that they had previously lost.

Details Concerning the Fungi.

The red-headed fungus (*Sphaerostilbe coccophila*) has been recorded from St. Vincent, Grenada, St. Lucia, Dominica, Montserrat, Antigua and St. Kitts. This last is a new locality for it, in the West Indies. The hosts recorded for it in these islands

are *Lepidosaphes beckii, Chionaspis citri, Chrysomphalus aurantii, Selenaspidus articulatus, Asterolecanium pustulans, Ischnaspis filiformis, Saissetia oleae, Saissetia nigra, Coccus mangiferae, Howardia biclavis, Coccus viridis* (?), *Dactylopus citri* (?), and *Diaspis* sp. (?).

A comparison with the previous paper on this subject will show that certain of these species were not then known to be attacked, in the West Indies. If the list given in Fawcett's paper on Fungi Parasitic upon Aleyrodes Citri, p. 29, is complete, then *Howardia biclavis, Saissetia nigra,* and *Coccus mangiferae* have not previously been recorded as hosts for it at all; in fact it was not known upon members of the genera Coccus and Saissetia. There seems to be no reason to doubt these records, and in the case of *Howardia biclavis* the writer examined specimens himself from St. Lucia, while a second record exists from St. Vincent. It may be noted that *S. oleae* had previously been recorded as a host from Antigua. *C. viridis* has twice been recorded as a host, once from Antigua, (*vide* previous paper, p. 20) and once since from Dominica; both these records are open to doubt

The white-headed fungus (*Ophionectria coccicola*) was formerly reported to occur in Dominica only, on *Lepidosaphes beckii.* On October 2 of last year it was forwarded from St. Lucia, and was identified by the writer; it was living on an unidentifiable scale insect, probably *Lepidosaphes beckii,* on an orange leaf. The same fungus also occurs in several places in Trinidad, though its presence there was formerly uncertain owing to its confusion with *Sclerodermis gigaspora,* Massee, to the possibility of which attention was called to the previous paper by the writer. Referring to this, Rorer writes as follows: 'This fungus [i.e. *Sclerocderris gigaspora*] was collected by Hart on scale insects on orange trees and sent to Kew where it was determined by Massee as a new species to which the above name was given. At the same time Mr. Hart sent the writer specimens from the same collection which were forwarded to Dr. Thaxter of Harvard University who found *Ophionectria coccicola* E. and E. on the scale insects.

'Later the writer sent specimens to Kew from the same collection made by Mr. Hart and asked if the scale parasite was *O. coccicola,* and received an affirmative reply.

'The attention of the Director of the Kew Gardens was called to the matter and he reported that there were two fungi parasitic on the scale insects, one *O. coccicola* and the other *S. gigaspora.* Since then the writer has requested specimens of the latter fungus but none have been received. The figures in the *Kew Bulletin* suggest Ophionectria rather than Scleroderris.' (Circular No. 4, Board of Agriculture, Trinidad, p. 38.)

The black fungus (*Myriangium Duriaei*) occurs in Barbados, St. Vincent. St. Lucia, Dominica, Montserrat, Antigua and St. Kitts, the two last being new localities for it.

The West Indian hosts recorded are *Lepidosaphes beckii, Chionaspis citri* and *Howardia biclavis.*

The shield scale fungus (*Cephalosporium lecanii*) has been found in Barbados, St. Vincent, Grenada, St. Lucia, Dominica, Monsterrat, Antigua, St. Kitts (?) and Tortola. St. Lucia,

St. Kitts and Tortola have been added since the previous record was made.

Its host plants so far recorded are: *Saissetia hemisphaerica*, *S. nigra*, *S. oleae*, *Coccus viridis*, *C. mangiferae*, *Pulvinaria pyriformis* and *Aphis gossypii*. Of these, *Pulvinaria pyriformis* is a new host, for the West Indies.

In February 1911 the shield scale fungus was found by the writer to be attacking the mealy shield scale (*Pulvinaria pyriformis*), on cinnamon trees in the Botanic Gardens, Grenada. Subsequently, it was also recorded on the same host by the Superintendent of Agriculture in Barbados, and by the Agricultural Superintendent in St. Vincent. It may be noted that this fungus was found to occur on the green scale (*Coccus viridis*) on limes in Montserrat, in a newly cleared field near bush land, though in most localities it is not found on lime trees in that island. Another point of interest is the record of its occurrence in the forest in St. Vincent, at a considerable distance from Kingstown. Its general distribution throughout the islands, joined with its discovery in their more remote parts, renders improbable the suggestion of its recent importation previously made.—(*West Indian Bulletin*, Vol. XI. pp 24 and 25.)

A white fungus, referred to as *Sporotrichum* sp., is reported by Tower as parasitizing *Saissetia hemisphaerica* in Porto Rico. The appearance of his Fig. 2 on Plate III, taken in conjunction with the identity of the host scale, suggests that possibly the Porto Rican fungus is in reality *Cephalosporium lecanii*. (Insects Injurious to Citrus Fruits and Methods for Combating Them. Bulletin 10, Porto Rico Agricultural Experiment Station.)

On November 15, 1909, specimens of the leaves of mango and star apple (*Chrysophyllum Cainito*) were forwarded from Dominica for examination. They showed the presence of a fungus occurring on small localized masses on their surfaces; the leaves themselves were green and did not appear sickly, but although it was suspected that the fungus was living on scale insects of which some specimens belonging to *Coccus mangiferae* were found on the leaves, yet no traces of the remains of the insects could be discovered in the stromata of the fungus. Specimens were forwarded to Kew for identification, and the fungus was said to be the conidial or Aschersonia stage of *Hypochrella oxyspora*, Massee. Its identity, taken in connexion with the appearance of the leaves, makes it probable that it is an insect parasite. It has since been found in St. Lucia and Antigua, usually accompanied by *C. mangiferae*; though on one occasion it was found on a lime leaf in Dominica, when it was probably parasitic on some other species of insect. Inoculation experiments will be conducted with this fungus as opportunity offers, and further observations will be made as to its distribution and hosts.

A popular description of the fungus was given in the *Agricultural News*, Vol. X, p. 190, which is as follows: 'It forms small, light-pink masses or stromata from which several small spherical bodies project. These are closed at first, but later on extrude short, cone-shaped, rose-coloured masses of spores. Later still, the spheres open out into shallow cups, lined with the

rose-coloured masses of spores. The spores themselves are borne on short conidiophores, lining the cavities of simple or branching pycnidia sunk in the bottom of the cups. Each spore is hyaline when seen by itself, and colourless, and is pointed at either end.'

On January 28, 1910, specimens of Gardenia showing dead Aphids upon which a fungus was growing were submitted to the writer for examination by Mr. H. A. Ballou, Entomologist to this Department. The fungus appeared to be a species of Hormodendron, and a sterile culture examined at Kew was determined as a Cladosporium. Thus it was probably one stage in the life-history of a Cladosporium, though the type of fructification characteristic of the latter form has not yet been seen. A very similar fungus was found on white fly forwarded by Mrs. W. H. Patterson from St. Vincent. On March 21, 1911, specimens of the glassy star scale (*Vinsonia stellifera*) attacked by a hymenopterous parasite and a fungus described as a parasite were received from the Superintendent of Agriculture, Barbados. In writing of the fungus, Mr. Bovell was apparently doubtful of its parasitism at that time, for he says, in his letter: 'With regard to the fungus, I have so far found it difficult to get really good specimens, showing hyphae in the body of the insect, and although at first I thought there was fungus in the insect itself, I am not now satisfied that it is so, and I am trying to obtain further specimens.'

This fungus was associated with the dead bodies of the scale insects themselves and also with those of the insect parasite. It proved to be a species of Hormodendron—probably the same as that found on the aphids and white fly. No inoculation experiments have been conducted with it by the writer, but it may well be a parasite, as is shown by the manner of its occurrence and spread. Mr. Bovell, writing under date of April 13, 1911, stated that he had obtained really good specimens showing the hyphae of the fungus in the body of the insect.

Thümen described a fungus named by him *Cladosporium aphidis*, which he found on the dead bodies of *Aphis symphytum*, in Austria; he states that it is not the same as *Cladosporium herbarum*, Lk., but that he does not know *C. herbarum*, var. *aphidis*, Fckl. These are the only references to the presence of species of Cladosporium on aphids, with which the writer is acquainted. Their connexion with the West Indian species cannot be decided until the latter has been more carefully studied.

One or two other species of fungi found in connexion with scale insects are also worthy of investigation, though up to the present nothing is known definitely with regard to them.

In conclusion, the author's thanks are due to various gentlemen in the different islands, and to the officers of the local Botanical and Agricultural Stations, for regular observations and other valuable assistance. The monthly observation cards have proved of special value, as the continuous records have shown very clearly the effect of the parasites on their hosts under different conditions. Far more intelligible information is obtained in this way than by casual letters recording a certain number of isolated observations. They have served to show the workers at head-

quarters very clearly the effects that might be obtained by the full development of the control exercised by these useful fungi. and thanks are especially due to those gentlemen and officers of the Department who have provided them.

REPORT ON THE PREVALENCE OF SOME PESTS AND DISEASES IN THE WEST INDIES, FOR 1910 AND 1911.

A Report on the Prevalence of Insect Pests and Fungus Diseases in the West Indies for the year 1909-10 was published in the *West Indian Bulletin*, Vol. XI, pp. 73-106. This report covered the period from April 1909 to June 1910. In the present report, two periods are covered—one referred to as Period A, extends from July 1910 to March 1911; and the other referred to as Period B, extends from April to December 1911.

The information presented in this report has been accumulated in the same manner as before; that is, blank forms have been submitted to the Agricultural Officers in each of the islands of the Windward and Leeward groups, and these have been filled in and returned. It should be mentioned, however, that for Grenada and St. Lucia returns are available only for Period B.

PART I.—INSECT PESTS.

BY H. A. BALLOU, M.SC.,

Entomologist to the Imperial Department of Agriculture.

SUGAR-CANE.

MOTH BORER.

ST. VINCENT. A. It was fairly prevalent.

B. It was in most fields, but the damage done was not extensive.

ST. LUCIA. B. It was reported to be present, but no information was available as to its prevalence.

ANTIGUA. A. There was no perceptible increase in the numbers of this insect over those of last year.

B. The moth borer was common in cane fields during the months of May, June, July and August, but did no serious damage.

ST. KITTS. A. It was to be found on almost every estate, but in no great quantity. Certain new seedling varieties under trial were badly attacked.

B. Only one serious outbreak occurred during this period. A field of plant canes was severely attacked in April, and the yield of sugar was much reduced

NEVIS. A and B. The moth borer has been observed, but no serious damage has been caused by the insect.

VIRGIN ISLANDS. A. The moth borer is common in the Bourbon cane, but is less common in Blue Ribbon and B. 147. B. 208 is somewhat liable to attacks. This insect causes a good deal of loss, especially in dry situations.

WEEVIL BORER.

ST. VINCENT. A. A few individuals were seen in different places.

B. This insect did not appear to be very prevalent.

ANTIGUA. B. It is common and widely distributed throughout the island. B. 156 is particularly susceptible to the attacks of this pest.

ST. KITTS. A. A field of plant canes on one estate was seriously attacked by this insect. The infested canes were dug up and burned, and many beetles were caught by light traps; after this there was no further spread.

B. A field of plant canes on another estate was seriously attacked. This was the same as that in which the canes had been severely damaged by termites. These are the only recorded attacks of the weevil borer during the periods under review.

NEVIS. A and B. It was not observed in the island during these periods, but it is known to have occurred in the past.

ROOT BORER.

ANTIGUA. B. Isolated insects (larvae) were found in June and July. N.B.—This appears to be the first record of its occurrence in this island.

ST. KITTS. A. Signs of this pest were seen in many fields of ratoons during the reaping season, and in some instances the stools were taken out and burned. This pest cannot be said, however, to be serious in St. Kitts.

B. No appearance of this pest has been noted.

CANE FLY.

No observations with regard to this pest are recorded in any of the islands.

TERMITES.

ST. KITTS. A. The area attacked by these insects has been considerably reduced, and owing to the use of a rotation crop of cotton for two years, it has been found possible to plant canes again in the fields formerly so seriously attacked. So far these canes have not been reinfested, and give promise of good results. No other attacks are recorded beyond this.

B. The insects were only found on the same estate as that referred to in previous reports. A fresh outbreak has taken

place in the last few months, in a field of canes near those formerly attacked. Experiments in the poisoning of the ants are in progress. This field is also attacked by the weevil borer and by root fungus.

MEALY-BUG.

ANTIGUA. A. It was common during the end of the period. B. It was of very frequent occurrence.

MISCELLANEOUS.

ANTIGUA. B. An unidentified caterpillar caused a certain amount of damage to the leaves in November. There was also a small amount of damage caused by grasshoppers.

ST. KITTS. B. Grasshoppers caused some damage to young canes.

Note.—Information concerning cotton pests in St. Lucia was supplied by the late Schoolmaster at the Agricultural School, who twice visited cotton localities.

COTTON.

COTTON WORM.

GRENADA. B. It was not found in the few fields planted.

ST. VINCENT. A. A few were seen, but were soon destroyed by predaceous insects. No damage was done, and no Paris green was necessary.

B. A few insects were seen, but no damage was recorded in St. Vincent, and no Paris green or other insecticide was used in this island. In the southern Grenadines and Mustique, some damage was caused.

ST. LUCIA. B. This insect occurred in considerable numbers, in certain fields.

MONTSERRAT. A. The first attack for the season was reported on September 9. Attacks were severe all over the island, more particularly on the windward side; and scorching of the leaves resulted in some cases. The local Jack Spaniard was observed on two occasions to be destroying these insects at Grove Station.

B. The first attack was reported at the beginning of August, and attacks were particularly severe in all parts of the island; where the earlier broods were not destroyed some damage was done. The worms were most abundant in November and the beginning of December. Paris green and London Purple were imported in about equal quantities, as insecticides. The internal parasite, *Chalcis* sp., has been reared from the chrysalis. There is no evidence to show that the Jack Spaniards imported from St. Vincent have increased, nor have they been seen to attack the cotton worm. The lesser cotton worm (*Aletia luridula*) appeared to be present in small numbers.

ANTIGUA. A. Very severe attacks were experienced during the months of October and November. It also occurred in a few isolated cases in February.

B. Severe attacks were experienced during the early part of December.

ST. KITTS. A. This pest has not caused any damage, owing partly to the absence of the worm and partly to the great care taken by the planters in observing the attack in the early stage and checking it at once by applying poisons.

B. The cotton worm was very persistent in its attacks during October, November and December. Fresh broods were constantly hatched out. Frequent showers rendered the application of poison ineffective, and damage was done to the plants in some cases.

NEVIS. A. The insects hardly appeared during the season. A supply of Paris green and lime is always kept in reserve.

B. This pest was very abundant and caused a certain amount of damage, especially in the southern portion of the island. The attacks were more difficult to control during this season than they have been for the past three years.

VIRGIN ISLANDS. A. There have been sporadic attacks. Natural enemies appeared to keep the pest under control, and no artificial means of checking its spread have been used.

B. No attacks were reported or observed, possibly owing to the fact that adverse weather conditions necessitated late planting.

BOLL WORM.

ST. VINCENT. A and B. This is always found on Indian corn, but has not been observed on cotton.

ANTIGUA. A and B. No attacks were recorded.

COTTON STAINERS.

GRENADA. B. These insects were common after the bolls had ripened. They were of a serious nature in one field.

ST. VINCENT. A. A fair number were present towards the end of the crop.

ST. LUCIA. B. These insects were present, but no damage was reported.

MONTSERRAT. A. This pest was reported to be causing trouble in one district, but it was not abundant on the principal estates in the windward and leeward districts.

B. The insects were numerous in many parts of the island and became abundant in some districts as early as August, though their distribution was not general throughout the island at that time. They are supposed to spread from the silk cotton tree (*Eriodendron anfractuosum*) which in the past year bore large crops of pods. The sea-side mahoe (*Thespesia populnea*) is also a natural food plant. The pest is more prevalent in the vicinity of forest or bush land. There is still some scepticism on the part of planters as to the actual amount of damage done; though, on several estates, attempts have been made to control the insects by collecting.

ANTIGUA. A. No severe attacks were experienced.

B. They were common during the end of the 1910-11

crop. A few insects were beginning to appear in December, in the early cotton fields of the current crops.

ST. KITTS. A. There was a considerable decrease in the numbers of this pest, and little if any damage was caused.

B. None were seen on this season's cotton crop, up to the date of the report.

NEVIS. A. These insects were prevalent, especially during the middle of the reaping season; but they are hardly ever allowed to do any damage as they are kept in check by collecting them in vessels containing a quantity of sea-water or kerosene and water.

B. These were not very prevalent in this season. This may be due to the fact that the cotton crop was established late in the year. Attacks are likely to be experienced later in the cotton season.

VIRGIN ISLANDS. A. They were troublesome in places, more especially in plots near the sea-shore. The Malvaceous tree known locally as the Haiti tree (*Thespesia populnea*) acts as a host for this pest. These insects are kept in check by collecting.

B. These insects were very prevalent at the end of the last cotton crop, February to June. None were reported or observed on the new crop. As a rule they do not appear in large numbers until after Christmas.

SCALE INSECTS.

GRENADA. B. The snow scale (*Hemichionaspis minor*) occurs on the stems of all old cotton plants.

ST. VINCENT. A. The black scale (*Saissetia nigra*) was fairly prevalent in the Leeward district towards the end of the crop, and also occurred on two or three estates on the Windward side.

MONTSERRAT. A. Scale insects are often more or less present at the close of the season. The black scale is present only in rare instances.

B. The black scale occurred occasionally, but could not be considered a serious pest. The parasite, *Zalophothrix mirum*, has been reared from this scale.

ANTIGUA. A. The snow scale and the black scale occurred on a few fields to a slight extent, towards the end of the season.

ST. KITTS. A. There were no scale insects on cotton trees in sufficient numbers to cause any damage. The fact that all the cotton is pulled up after the first picking in January prevents these pests from becoming established.

B. The black scale was observed in a few instances.

NEVIS. A. These were observed in one field near where a number of Hibiscus plants was growing in a garden.

B. None were observed up to the date of the report.

VIRGIN ISLANDS. A. The white scale was seen on Curaçao cotton in a few instances, but not on Sea Island plants.

B. Scale insects were observed on old bushes of the native varieties of cotton, but not on Sea Island trees.

FLOWER-BUD MAGGOT.

MONTSERRAT. A. Its presence at the close of the season 1909-10 was doubtful, and there was no evidence of its attack in the season under review.

B. It was first reported about the middle of October, on cotton planted at an elevation of about 300 feet; during November it was found on several estates in different parts of the island. On none of the affected areas was the maggot responsible for the total loss of the bolls developing at the time of the observation, though the actual proportion of affected buds was not calculated. The loss due to it is probably not great, owing to the unsatisfactory nature of second pickings, that is, bolls developed after November, whether the insect is present or not.

ANTIGUA. A. The insect appeared late in December, and the attack extended through January and February into March, when it entirely ceased. Isolated specimens were found as late as April, in the southern part of the island. The most serious attacks occurred in the central plain and in the northern and windward districts of the island.

B. The insect made its appearance in one instance in November.

LEAF-BLISTER MITE.

GRENADA. B. It is practically unknown in this island, but a few cases were observed in the southern district.

ST. VINCENT. A. It was chiefly to be found at the end of the crop season. On a few estates, where the destruction of old cotton bushes was delayed until near the time of planting the new crop, some damage was done.

B. It was plentiful at the end of the last crop season. The new crop was not badly attacked at the time of this report, that is in December.

ST. LUCIA. B. A few plants were attacked here and there.

MONTSERRAT. A. It was not prevalent during this season. The old plants were as usual destroyed before the crop was planted.

B. This pest was more generally prevalent than it has been for many years past, and this may be accounted for as follows. In the first place the drought in March and April rendered it difficult to destroy the old plants, while in the second, the new crop was planted early—in fact during the first two weeks of May—so that only a very short time elapsed between the destruction of the old plants and the establishing of the new crop. It is also recorded that the drought in August favoured the development of the pest. Badly infested plants recovered to some extent, on the advent of rains in September.

ANTIGUA. A. This pest was less abundant than it has been in previous years; though it was fairly common on early planted cotton, especially late in the season, when it also became more general.

B. A few fields of young cotton were attacked, but on the whole, up to the date of the report, the crop was fairly free from this pest.

ST. KITTS. A. This pest was of general occurrence, and in a few instances caused some damage. It does not generally appear until near the end of the cotton season. It was prevalent on old cotton in December. The application of sulphur and lime as a remedy is seldom, if ever, necessary.

B. During this season this pest was more abundant as a result of the drought in June and July. On estates where as a rule one picking is expected, this mite has caused but little damage, but its attacks seriously interfere with a second picking.

NEVIS. A. During the season up to the end of December, there was but little evidence of the presence of the leaf-blister mite. It is generally to be found especially in cotton fields when the plants begin to put out a secondary growth.

B. This pest was more prevalent than it had been for the past three years; hand picking and burning of infested leaves is the method of control usually employed.

VIRGIN ISLANDS. A. It was not so prevalent as usual in Tortola, but was abundant in Virgin Gorda at the end of the crop season.

B. A few instances of attack were reported on the new crop at Virgin Gorda. None were recorded in Tortola up to date of this report.

MISCELLANEOUS.

GRENADA. B. The green bug (*Nezara viridula*) infested the stems and young shoots of cotton in the Southern district. Its attacks were not serious at the date of the report. During October and November, large numbers of Sea Island cotton flowers were destroyed by a beetle—one of the hard-backs (not identified). This beetle eats away the bases of the petals, stamens and ovary.

MONTSERRAT. A mealy-bug was fairly abundant on the stems of old cotton plants at the time of writing the report. It attacked the main stems, lateral branches, flower stalks and bolls. It did not appear until late in the season, and was of general distribution on the leeward side of the island. It had been noticed in small numbers in previous years, and was perhaps not more plentiful this season than usual.

ANTIGUA. A. A few slight attacks of *Aphis gossypii* were experienced during the early part of the season.

B. The red spider (*Tetranychus telarius*) occurred on one field in the eastern part of the island, but caused no material damage. A small area of young cotton in the same district was attacked by weevils.

ST. KITTS. A. The late-planted cotton in many places was attacked on the upper leaves by a small mite. The leaves presented a crinkled and scorched appearance, and no bolls were produced on the upper branches. This occurred only in the case of late-planted cotton, and seemed to be associated with an abnormal growth following heavy rains.

B. An attack similar to that recorded above was noted during the season.

(Note.—Specimens of leaves affected in this manner were received at the Head Office, both from St. Kitts and Nevis. Careful examination by both the Entomologist and the Mycologist failed to reveal the presence of any insect, mite or fungus which would satisfactorily account for the peculiar appearance. The fact that it followed periods of heavy rainfall would indicate that it may be due to climatic conditions.—H. A. B.)

NEVIS. A. A slight attack of cut worms occurred on one estate; this was checked by the use of poisoned bait.

B. A severe attack of Aphis was experienced in one field during the season.

VIRGIN ISLANDS. B. A small beetle (not yet identified) caused a good deal of damage to young cotton. The insect appears to live in small burrows or holes in the ground, and emerges at night. The greatest damage to plants is inflicted before the cotyledon stage is passed, as the newly germinated plants are cut off. After this, the insect appears to cause little injury. No remedial measures were employed. It would appear that in good growing seasons the plants pass the stage at which they are liable to attack quickly enough to allow a sufficient number to develop into mature plants, and in such a case the attacks are not as serious as in a dry season, when growth is slow and a large percentage of plants is liable to be lost.

CACAO.

THRIPS.

GRENADA. B. Several severe attacks were experienced in all districts.

ST. VINCENT. A. They were not very prevalent.

B. They have done a considerable amount of damage on several estates.

ST. LUCIA. B. They were fairly common, but no serious outbreaks were reported.

DOMINICA. A. They were present in small numbers.

B. A few are always present but there has been no epidemic.

VIRGIN ISLANDS. A. None had been observed since the last report.

CACAO BEETLE.

GRENADA. B. This was common in the western district; it was not reported from any of the other islands.

SCALE INSECTS AND MEALY-BUG.

GRENADA. B. Isolated attacks of mealy-bug were noted, but they were not of a serious nature.

DOMINICA. B. A few occurred round the buds and young fruit, but not in sufficient numbers to cause any damage.

ST. KITTS. B. Mealy-bugs occurred on the trees on one estate; no great damage seemed to have been done by them.

NEVIS. B. Scale insects and mealy-bugs were observed on one estate, and were thought to have caused some damage to the flower buds. Spraying with Abol mixture was adopted with fair success.

VIRGIN ISLANDS. A. Some mealy-bugs occurred and were distributed by ants. They were troublesome on young cacao.

B. Mealy-bugs were present on cacao plants at the experiment station: they occurred chiefly at the base of the young pods.

MISCELLANEOUS.

GRENADA. B. Black aphis was common on the west coast, on young suckers. Their attacks appear to be governed by conditions similar to those governing the attacks of thrips.

ST. KITTS. A. A few trees on one estate died, apparently as the result of the attack of some boring insect which has not been identified. The attacks have not increased.

B. The occurrence of a grub tunnelling under the bark of cacao trees has been noted, but nothing much seems to be known as to the nature of the attack or the damage inflicted. Hemipterous insects were also reported as attacking cacao flowers.

NEVIS. B. Aphids, which are followed by a large black ant, were found on cacao on one estate. The ants were prevented from ascending the trees by the application of a band composed of a mixture of tar and grease at a height of about 1 foot from the ground. The aphids were controlled by spraying.

VIRGIN ISLANDS. A. During the period August to October, following rainy weather, a brown and green beetle attacked cacao trees and fed on the young leaves.

LIMES AND OTHER CITRUS PLANTS.

SCALE INSECTS.

GRENADA. B. The green scale (*Coccus viridis*) was common on young shoots, and the snow scale (*Chionaspis citri*) on stems and older branches. The purple scale (*Lepidosaphes beckii*) was common in all districts.

ST. VINCENT. A. All the citrus trees are gradually being killed. There was no change in the general situation since the last report.

B. There was no change in the general situation, and the number of citrus trees was further reduced. The purple scale, the snow scale, the green scale and the West Indian red scale (*Selenaspidus articulatus*) occurred in very large numbers.

ST. LUCIA. B. The green scale, the purple scale and the snow scale occurred on limes. They were fairly well controlled by their respective parasitic fungi. The orange-red scale (*Chrysomphalus aurantii*) occurred on oranges. This was parasitized to a certain extent by the red-headed fungus (*Sphaerostilbe coccophila*).

DOMINICA. A. Scale insects were present, but were well under control. A severe outbreak, attended by black blight, occurred on one estate in February.

B. Scale insects are always present, but do not often attain to any considerable numbers. They continue to be well kept in check by their natural enemies.

MONTSERRAT. A. There were no striking developments of scale insects during this period. The red fungus is present in most districts where citrus plants are grown. The green scale has, if anything, decreased in numbers. The orange-red scale was noted in January, in quantity on one field of limes. At the end of this period the scales were reported to be less in number than in the previous year, and considerably less than in the year before that.

B. The purple scale has been the most prominent in the lime cultivation on two estates in the leeward district near Plymouth, and sections in various fields show the abnormal development of these insects which often results in the death of, or very serious injury to, the trees. The green scale and the Lantana bug (*Orthesia insignis*) were not abundant. In two districts with a low rainfall the prevailing pest is the snow scale ; there is very little purple scale to be seen. In one district with high rainfall, in the southern part of the island, the purple scale made serious development over a large area, and many trees were killed.

ANTIGUA. A. Scale insects were common on all citrus trees, but there was no appreciable increase in their numbers, and the trees in one young plantation were noticeably free from them.

B. These insects were of general distribution in the island, but appeared to be kept in control by natural enemies.

ST. KITTS. A and B. Scale insects are reported to attack citrus plants in all parts of the island.

VIRGIN ISLANDS. A. The snow scale occurred on exposed trees ; those growing in sheltered situations were not much attacked. This scale is more numerous in dry seasons such as that included in this period.

B. The snow scale was abundant during the dry months June to September. Other scales occurred in smaller numbers.

BORER.

No observations.

FRUIT FLY.

DOMINICA. A. The occurrence of this insect on orange trees is reported at the Botanic Station ; it has not been proved, however, that the insect which causes the injury to the fruits is the fruit fly.

MISCELLANEOUS.

ST. LUCIA. B. The rust mite (*Phytoptus oleivorus*) was reported on orange fruits at Union. *Ormenis* sp. occurred on lime trees (Lu. 2973/11) and aphids on orange leaves (Lu. 1009/11).

MONTSERRAT. B. The leaf-eating beetle (*Epicaerus ravid*) was noticed to be fairly plentiful and doing some damage to a field of young limes on one estate.

VIRGIN ISLANDS A. Beetles ate some of the young growths.

RUBBER.

SCALE INSECTS.

GRENADA. B. An unidentified mealy-bug occurred on Castilloa.

ST. VINCENT. A. Castilloa was badly attacked by these pests.

B. These were still numerous on Castilloa. The red-headed fungus (*Sphaerostilble coccophila*) was seen on insects at the Botanic Station.

ST. LUCIA. B. None were observed. or reported to be doing any injury.

DOMINICA. A. These were present on Castilloa and Funtumia, but were under control.

B. Castilloa is annually attacked by a white scale which becomes sufficiently numerous to attract attention just before the change of leaf. Shield scales are sometimes found on the bark of Para rubber trees.

MONTSERRAT. B. Castilloa trees are invariably attacked by the akee fringed scale (*Asterolecanium pustulans*). This often results in the death of the main shoot.

ST. KITTS. A. Mealy-bug was recorded on all the Castilloa trees on one estate, but it did not appear to affect their development and no remedial measures were adopted.

B. The mealy-bug and scale insects attacking Castilloa on the same estate had much decreased in numbers.

VIRGIN ISLANDS. A. The only rubber plants under observation were a few trees at the Botanic Station. A green scale and a mealy-bug were recorded as troublesome. A species of Aspidiotus was also present.

B. The same insects were again present. The Superintendent of Agriculture for the Leeward Islands adds the following note for period B: 'Scale insects were fairly common on Castilloa in Dominica, Antigua, St. Kitts and Nevis.'

SWEET POTATOES.

SCARABEE.

ST. VINCENT. A. This was found in nearly all fields, and did serious damage in some places.

B. It is nearly always present, and is particularly serious in fields which are not reaped as soon as the potatoes are ripe.

ANTIGUA. A. The crop was noticeably free from this pest.

B. The crop was fairly free from this pest, but was damaged by drought.

ST. KITTS. A. No instance of damage from this pest has been recorded. It does not seem to be common in this island, and has never attacked any plots in the experiment station.

NEVIS. A. It was not observed.

B. It was noted during October, in one field.

CATERPILLARS.

ANTIGUA. A and B. A few isolated attacks occurred.

ST. KITTS. A and B. There was no appearance of this pest.

VIRGIN ISLANDS. A. Sporadic attacks occurred during October and November.

B. An unidentified worm, possibly this insect, occurred during March and April.

RED SPIDER.

ANTIGUA. A and B. A few isolated attacks were recorded.

ST. KITTS. B. It did not occur in sufficient numbers to cause any damage.

VIRGIN ISLANDS. A. It was noted in dry, sandy places, at Beef Island and Virgin Gorda.

THRIPS.

VIRGIN ISLANDS. A. They were noted in dry, sandy places, at Beef Island and at Virgin Gorda.

GREEN DRESSINGS.

LEAF-EATING CATERPILLARS

GRENADA. B. Slight attacks were reported on young cowpeas, in the southern district.

ST. VINCENT. A. Woolly pyrol was badly attacked at the Agricultural School. Bengal beans were attacked, but not to a serious extent.

B Woolly pyrol was badly attacked, at the Agricultural School.

MISCELLANEOUS.

DOMINICA. B A red spider has been found doing considerable damage on green dressings, Bengal beans, Jerusalem pea, and the horse bean in its later stages. Pigeon peas are much injured annually by green fly.

MONTSERRAT. A. The woolly pyrol moth (*Thermesia gemmatalis*) was of general occurrence on Bengal beans; whole areas were severely attacked. Bengal beans which are grown for green dressings on cotton lands are generally cutlassed as soon as the attack begins, hence the advantage of establishing

the dressing at an early date, as the caterpillar usually appears after September. In this year, it was most plentiful in October and November. Two instances have been noted where beans covering lime trees have not been attacked, while those covering the intervening spaces between the trees were destroyed.

B. No attacks were recorded, up to the date of writing the report.

ANTIGUA. A. Several severe attacks were experienced.

B. Attacks were common, but were probably not as serious as in former years.

ST. KITTS. A. Bengal beans and woolly pyrol were attacked by caterpillars, wherever planted. The custom now is rather to plant these beans as green dressings as this plant seems to resist the pest. A trial has also been made with the Barbuda bean, with success. In the northern district, pigeon peas are still successfully grown as green dressings.

GROUND NUTS.

MEALY-BUGS.

MONTSERRAT. B. These were fairly common on the nuts, at the time of reaping.

MISCELLANEOUS.

MONTSERRAT. A. An unidentified caterpillar was observed to be eating the leaves, but the attack was slight.

ONIONS.

CATERPILLARS.

MONTSERRAT. B. They were reported on young onions, in one section.

ANTIGUA. A. Slight attacks occurred, but they were in no way serious.

NEVIS. B. Caterpillars caused damage during the first week in December, at the Experiment Station and in a few other localities. A poisoned bait was used, with excellent results.

THRIPS.

MONTSERRAT. A. Severe attacks of these insects were noted in a few cases, in February.

ANTIGUA. A. The crop was free from this pest, for most of the year. A few mild attacks were experienced during March 1910.

INDIAN CORN.

EAR WORM.

GRENADA. B. Fairly common in many fields in the southern district.

MISCELLANEOUS NOTES.

ST. LUCIA. B. Mites on house-fly and lace bugs on egg plants.

DOMINICA. A. Insect pests were comparatively scarce.

Antigua. B. Small black lady-birds, probably predaceous on *Chionaspis citri*, are common in the southern district.

ST. KITTS. A. and B. Only the usual insect pests of staple crops occurred, and these caused no serious damage.

ST. VINCENT. A. Scale insects continued to do a great deal of damage to fruit and other trees.

PART II.—FUNGUS DISEASES.

BY F. W. SOUTH, B.A. (CANTAB.),

Mycologist to the Imperial Department of Agriculture.

The information presented in this portion of the paper has been obtained from the same sources, and is dealt with in the same manner, as that provided in Part I.

SUGAR-CANE.

ROOT DISEASE (*Marasmius* spp.).

ST. VINCENT. A. This has been the cause of much damage on certain estates where sugar-cane has been grown continuously over a long period of time.

B. No complaints of damage were received, but it was noticed in fields of ratoon canes.

ST. LUCIA. B. A root disease was plentiful on some estates.

DOMINICA. B. It was recorded on two estates.

ANTIGUA. A. The disease is extremely common, and occurs on nearly every estate in the island. The dry weather of the season under consideration rendered the effect of the disease very evident.

B. It was extremely prevalent throughout the island, and was particularly noticeable in dry months, and on ratoon canes growing in heavy soil.

ST. KITTS. A. This disease was found in many fields of ratoons, and in many instances the stools were dug out and burned. It does not seem to be on the increase, and at the present time there would appear to be no cause for alarm, where care is taken to obtain good plants and where the land is well manured.

B. The disease increased considerably in this season on account of the prolonged drought, and the variety B. 208 was somewhat affected in certain districts.

NEVIS. A. It inflicted some damage on the young cane crop, on three estates.

B. It was present in many fields on the same three estates, while supplementary observations would indicate that it is generally present throughout the island.

VIRGIN ISLANDS. B. Canes appear to be almost free from this disease; ratooning is carried on for a more or less indefinite period.

The writer made an examination of the position in Antigua in July 1911, and found that the disease was most serious on

the heavy soils. Recommendations as to the measures likely to be of service in combating the disease were prepared by the Superintendent of Agriculture for the Leeward Islands in collaboration with the writer, and issued in the form of a circular for distribution to planters.

RIND DISEASE (*Melanconium sacchari*, Massee).

ST. VINCENT. A. It was fairly common on the Bourbon cane, but was not as much in evidence on the newer varieties.

B. It is always present, but is only limited in extent, except in fields of Bourbon canes.

ST. LUCIA. B. A so-called rind disease is common on some estates.

ANTIGUA. A. The effect of this disease was not noted during the period.

B It was common on over-ripe canes; the fructifications of *Melanconium sacchari* always appear on canes that have been cut for a few days; the fungus often occurs on canes that have been badly attacked by root disease.

ST. KITTS. A. This disease was only seen in a few instances, and was confined chiefly to canes grown under unfavourable conditions. In one case it was noticed on a few canes of B. 208.

B. A few instances of its occurrence were noticed during the reaping season, but in no case was it sufficiently prevalent to cause any alarm. On one estate, B. 208 is thought to be liable to attack, and is not planted to as large an extent as it was formerly.

The parasitic nature of this fungus is still a matter of doubt, and there is a possibility that the disease recorded in St. Vincent and St. Kitts may have been primarly due to the red rot fungus (*Colletotrichum falcatum*).

RED ROT (*Colletotrichum falcatum*, Went).

ST. LUCIA. B. A disease which causes the interior of canes to turn red, and appears to start in the fibrovascular bundles, is common on some estates. In affected canes, the tissue of the internodes shrinks and a cavity is formed in the centre of each. Specimens examined by the writer showed fructifications of *Colletotrichum falcatum* on infected nodes. So that this was almost undoubtedly true red rot.

ANTIGUA. A. The disease was not noticeable.

B. Isolated cases were not infrequently to be found.

MISCELLANEOUS.

ANTIGUA. B. A leaf spot disease due to *Leptosphaeria sacchari*, Breda de Haan, was fairly common near St. John's.

COTTON.

ANTHRACNOSE (*Glomerella gossypii*, Edgerton).

GRENADA. B. It was reported in the southern district, and was moderately severe in one field.

ST. VINCENT. A. It was fairly prevalent in the wetter districts.

B. It was fairly prevalent throughout the island.

MONTSERRAT. A. This disease is not well known in the island, and the presumption is that it is not present to any extent.

B. It is not a recognized disease in Montserrat at present.

NEVIS. A. The disease is not of frequent occurrence, and can only be found in damp districts.

B. It was not observed up to the date of the report.

BACTERIAL BOLL DISEASE.

BLACK ARM.

ANGULAR LEAF SPOT.

ST. VINCENT. A. A large number of bolls was attacked, and a high proportion of these was destroyed. It caused a fair amount of damage on the leaves, as its spread was encouraged by wet weather in September and October.

B. This disease was very prevalent, as the season was wet, and much damage was done.

ST. LUCIA. B. It occurred to some extent on the leaves, but no damage resulted.

MONTSERRAT. A. It was noted in most sections of the island, but did not apparently cause serious loss. It may, however, be responsible to a considerable extent for the staining of the lint in the bolls. The spotting of the leaves is to be seen in most fields of cotton planted on both light and heavy soils. It was noted that certain plants were particularly susceptible. Later in the year, black arm appeared to be common on the lateral branches.

B. The spotting of the leaves was not as plentiful as in the previous season. It is suggested that the drier season was unfavourable to the development of this form of the disease, and the same appears to be true of its manifestation on the bolls. Black arm was seldom met with, and affected the stems and lateral branches only to the extent of causing a black patch on the bark. Spotting of the leaves was of general occurrence, in one field on the windward side that had made secondary growth in November.

ANTIGUA. A. The boll disease appeared at the end of the season, but the leaf disease was not observed.

ST. KITTS. A. The disease of the bolls was generally present, but only caused damage in fields situated in damp districts, where it rendered the bolls black and hard. Where the conditions are favourable to cotton, the black marks are to be seen on the bolls, but no damage is done to the lint. The leaf spot is common, but only causes loss where the rainfall is heavy, or when cold and damp weather prevails.

During the season under review it appeared after the heavy rains, to an alarming extent, even in the dry districts, but the hot weather which followed seemed to prevent its spread. In rainy districts it caused much loss.

B. The boll disease did not occur to any extent. The leaf spot was noticed in some fields, but the weather was dry and little damage was done.

NEVIS. A. The boll disease was observed in a plot where the cotton was planted too closely, and where more light and air were consequently required. The leaf spot was observed in a few localities, but no appreciable damage was caused by it.

B. The boll disease was not noticed up to the date of this report. The leaf spot occurred in a few localities, but caused no damage. Black arm was noted on a small scale in a few places.

VIRGIN GORDA. A. A disease of bolls, believed to be this, was noted at Virgin Gorda.

WEST INDIAN LEAF MILDEW.

ST. VINCENT. A. It was fairly prevalent during October and November.

B. It was very prevalent after October, as the season was wet.

MONTSERRAT. A. It was more prevalent than it had been in previous seasons. One field showed the disease at an early date, and was leafless at the end of October. The field was closely planted, but it gave a good crop.

B. It was not more noticeable than usual.

ANTIGUA. A. It was fairly common on early planted cotton.

B. It was common on fields of older cotton.

ST. KITTS. A. It was not so prevalent as it had been in previous seasons.

B. It was not observed.

NEVIS. A. It was not observed during the season.

B. It was not observed up to the date of the report.

MISCELLANEOUS.

MONTSERRAT. A. A fungus root disease was thought to be present when plants were in the seedling stage. This, if a specific disease, evidently does not cause much loss at the present time. At a later date a considerable loss of bolls growing near the ground was observed; it was uncertain if this was due to a specific disease. (Specimens examined showed a soft rot of the boll associated with the presence of *Pythium* sp., or *Phytophthora* sp., to which fungus the damage was probably due. The material examined was preserved in spirit so that the true identification of the fungus was impossible.—F.W.S.)

ST. KITTS. A. There were instances of the premature dying down of cotton bushes, associated with a reddening of the leaves resembling the attack of rust (*Uredo gossypii*, Lager.).

CACAO.

ROOT DISEASE.

GRENADA. B. This is fairly common in wet lands on the banks of streams and in the heights. In no cases have the attacks been wide-spread although they occur in all districts.

ST. VINCENT. B. It was found by the Mycologist on young plants on two estates, and, possibly in a different form, on an older plant on a third estate.

ST. LUCIA. B. The distribution of this disease was general; it was most troublesome in the Etang district of Soufrière.

DOMINICA. B. Root disease is prevalent where trees are grown under unfavourable conditions.

ST. KITTS. B. A few of the older trees on one estate died, apparently from some root trouble; but no definite conclusions could be arrived at as to the actual cause of their death

CANKER (*Phytophthora Faberi*, Maublanc).

GRENADA. B. This is found in all districts, but is under effective control.

ST. VINCENT. A. It occurred to a considerable extent on one estate.

B. Very little canker was seen.

ST. LUCIA. B. It was common. It is under control on well-worked estates.

DOMINICA. A. It was present on delicate varieties of cacao.

ST. KITTS. A and B. This was found on a few trees on one estate: but they were promptly treated, and there was no spread.

DIE-BACK AND STEM DISEASE (*Thyridaria tarda*, Bancroft).

ST. VINCENT. B. It is apparently of rare occurrence. A condition resembling die-back is caused by thrips.

ST. LUCIA. B. It was common throughout the island, but no special cases had come under observation during the period.

DOMINICA. B. It was confined to the Alligator and Criollo types; hardier varieties were not attacked.

VIRGIN ISLANDS. A. Stems were noticed to be dying back, chiefly in times of drought. It was not certain if this was due to the fungus or to bad climatic conditions.

BROWN ROT OF PODS (*Thyridaria tarda*).

GRENADA. B. This occurs in most districts.

ST. VINCENT. A. It is rare.

B. Very few cases of this disease were seen.

DOMINICA. A. A few pods affected with this disease are found at each picking, but it is not of a serious nature.

B. It is generally present on estates, but does not cause serious damage.

BLACK ROT (*Phytophthora faberi*).

GRENADA. B. It occurs in most districts.

ST. VINCENT. A. A fair number of pods are attacked in all districts.

B. It occurs in all plantations, but the extent of the damage is difficult to estimate.

ST. LUCIA. B. It is common throughout the island.

DOMINICA. A. It is usually found in conjunction with canker, on delicate varieties.

B. It is associated unmistakably with stem disease (canker).

PINK DISEASE (*Corticium lilacino-fuscum*, B. and C.).

ST. LUCIA. B. It is present, but is of rare occurrence. No cases were noted during 1911.

THREAD BLIGHTS.

GRENADA. B. One case was reported on cacao.

ST. LUCIA. B. None were observed or reported.

HORSE-HAIR BLIGHT (*Marasmius equicrinis*, Mull.).

GRENADA. B. One case occurred in St. Andrew's parish. The tree was in contact with a badly infested nutmeg plant.

ST. LUCIA. B. None were observed or reported.

MISCELLANEOUS.

ST. VINCENT. B. A pod disease due to *Colletotrichum* sp. was observed; it was not of a serious nature.

LIMES AND OTHER CITRUS PLANTS.

ROOT CANKER (*Fomes lucidus*, Fr. ?).

MONTSERRAT. A. No additional evidence was available to show the amount of damage caused by this disease.

B. Several fields that had been in a healthy condition for many years showed symptoms of this, and in one instance an acre of trees entirely succumbed. Numerous brackets of *Fomes lucidus* were found on these trees. Brackets have also been found, in sporadic cases, on trees that have presumably succumbed to root disease.

ANTIGUA. A. This was not increasing.

B. It appeared that the disease was not spreading, or at least was only doing so very slowly.

BLACK ROOT DISEASE (*Rosellinia* sp.).

ST. LUCIA. B. This was present to a limited extent, and was just recorded on these hosts in 1911.

DOMINICA. A. Lime trees frequently die out on newly formed estates, owing to this and to the red root diseases.

Digging up and replanting are recommended as remedial measures. Coast estates hardly ever suffer from these diseases.

B. Sporadic instances of this disease are of common occurrence on estates in the interior, and formed the subject of an investigation by the Mycologist during September 1911. The results of this are given in the *Agricultural News*, Vol. X, p. 366, and will form the subject of a separate paper to be read at the Conference.

RED ROOT DISEASE (*Sphaerostilbe* sp.).

DOMINICA. B. This, like the above, is of sporadic occurrence and is limited to interior estates. An account of it appears in the *Agricultural News*, Vol. X, p. 382.

MISCELLANEOUS.

MONTSERRAT AND ANTIGUA. B. Melanose was observed in these two islands.

DISEASES OF RUBBER PLANTS.

SEEDLING DISEASE OF *Hevea brasiliensis*.

DOMINICA. A. An unidentified fungus disease of seedling Para rubber trees broke out in the nursery at the Botanic Gardens in March, but it was soon brought under control by the use of Bordeaux mixture and a mixture of lime and sulphur.

B. This disease did not occur during this period.

BLACK ROOT DISEASE (*Rosellinia* sp.) ON CASTILLOA.

GRENADA. B. A fair number of cases, about twenty, occurred.

ST. LUCIA. B. One case was recorded.

DOMINICA. B. It was only found where Castilloa was grown under unsuitable conditions.

SWEET POTATO.

ROOT DISEASE (*Marasmius* sp.).

ANTIGUA. A mycelium very similar to that of *Marasmius sacchari* was commonly found on sweet potatoes during this period. It is most noticeable in fields where potatoes are planted immediately after sugar-cane.

MISCELLANEOUS.

DOMINICA. A. An unidentified fungus was reported on the leaves and stems of plants growing in the interior of the island.

YAMS.

TUBER DISEASE.

ST. LUCIA. B. Some tubers become black inside, and hollow, after being stored for a few months.

GROUND NUTS.

ROOT DISEASE.

DOMINICA. A. This disease was not reported during the year.

B. No ground nuts were grown on the experiment plots.

MONTSERRAT. B. Root disease was believed to be present on the experiment plots at Grove Station, but it occasioned only slight loss.

ST. KITTS. A. There were no signs of this disease in the experiment plots, and it was not reported from elsewhere.

NEVIS. A. The Red Spanish variety, only, was attacked to a slight extent

RUST (*Uredo arachidis*, Lagh.).

DOMINICA. A. It occurred in the various plots, but the attack was not serious.

MONTSERRAT. A. It was very plentiful on the experiment plots. The results obtained from the use of Bordeaux mixture during the season support the theory that the disease shortens the life of these plants. The section sprayed remained green for a longer time than did the unsprayed section, and there was a considerable development of the fungus on the latter section, at a time when it could scarcely be found on the former.

B. It was prevalent on all the varieties under cultivation in the experiment plots; the Carolina Running suffered most, and the Gambia variety least of all. Spraying experiments with Bordeaux mixture did not yield any definite results; in fact they rather indicated that little or no damage is caused by the fungus. It was noticed that the actual number of pustules on the sprayed portions was small compared with that on the unsprayed, but tests for yield and quality showed no consistent results. (See *Agricultural News*, Vol. XI, p. 14.)

ST. KITTS. A. Leaf rust appeared on the experiment plots when the vines were maturing. Spraying with Bordeaux mixture gave good results.

LEAF SPOT (*Cercospora personata*, E. and E.).

DOMINICA. A. This did not attack the crop during this period; though it did considerable damage in the previous year.

MISCELLANEOUS.

GRENADA. B. No ground nut diseases were reported; the fungus root disease is, however, annually recurrent.

DOMINICA. B. No ground nuts were grown during the year under review.

ST. KITTS. B. Owing to the drought during the growing season, the results obtained from the experiment plots were unsatisfactory, but there was no appearance of any disease among the vines or nuts.

ONIONS.

BACTERIAL ROT.

MONTSERRAT. A. The only instance observed was at Grove Station, where the plants were attacked when nearly mature. It ultimately caused some loss, through decay, after the reaping of the crop.

NEVIS. A. This only occurred some time after the onions had been gathered.

VIRGIN ISLANDS. B. Onions kept well during this season.

MAIZE.

ROOT DISEASE.

ANTIGUA. A. Some isolated fields were rather badly attacked, but the damage was not so severe as that inflicted in the previous season.

B. Isolated instances of this are common, but it has not assumed the serious proportions possessed by it two years ago.

ST. KITTS. A. This disease has caused much loss from time to time; signs of it were seen, but it was not as prevalent as in past years. Two estates that planted corn grown at the Experiment Station obtained good returns, and there was no disease. Maize is not planted largely on estates in St. Kitts.

B. There was not so much of this disease seen, during the two years under consideration, as there has been in previous seasons. On account of the drought, only a small amount of corn was raised.

MISCELLANEOUS NOTES.

GRENADA. B. In St. Andrew's parish several nutmeg trees were seriously attacked by horse-hair and thread blights. Isolated cases of a fungus root disease occurred on pigeon peas in November; all cases were fatal. Mistletoe is a fairly extensive pest on cacao in the mountain lands, and love vine (*Cuscuta* sp.) in waste lands.

ST. VINCENT. A. Fungus and bacterial diseases of cotton were of sufficient extent to cause anxiety, but a fair crop was obtained ultimately.

B. An arrowroot disease known as 'burning' was reported upon by the Mycologist during the period (see *Agricultural News*, Vol. X, p. 174).

ST. LUCIA. B. An entomogenous fungus new to the island (*Hypochrella oxyspora*, Massee) was found on scale insects.

DOMINICA. A. Fungus diseases were not in evidence, and the conditions generally were very favourable to plant growth.

B. Mistletoe was generally prevalent on the older lime estates. The necessity for removing this parasite has been recognized generally during the last two years, and the work of removal is becoming part of the estate routine. The love vine occurs in the La Plaine and Portsmouth districts, on limes.

MONTSERRAT. B. Love vine or dodder (*Cuscuta* sp.) was reported to have taken possession of about 3 acres of cotton in spite of repeated attempts to control it. The cotton was abandoned. This was in a remote spot adjacent to forest, at the north of the island.

ANTIGUA. B. The love vine appeared to be increasing in certain districts—All Saints parish and the southern parts of the island. Parasitic fungi on scale insects proved to be commoner in the southern district than was expected.

ST. KITTS. A. Only the usual diseases of staple crops were recorded, and these did not cause serious damage.

B. The same was true of this period, though some harm was inflicted on sugar-canes by drought, in one district. The love vine was fairly common, but did not occur on plants of any value.

VIRGIN ISLANDS. A. Very little attempt is made to investigate plant diseases and insect pests in Tortola.

B. Love vine and mistletoe seemed to be on the increase.

METEOROLOGICAL CONDITIONS.

ST. VINCENT. A. This was a fairly satisfactory season; there was rather too much rain in August and September for cotton, but other crops did not suffer.

B. The season was very wet, and in most districts the rainfall was much above the average.

ST. LUCIA. B. In April and May, unusually wet weather was experienced; while in October and November a period of comparative drought occurred. In other respects the season was normal.

DOMINICA. A. The weather was, on the whole, very favourable to plant growth. The rainfall was somewhat excessive during July, August and September 1910, but the season was otherwise normal. There were no serious storms, with the exception of one in the south windward portion of the island, in February 1911.

B. On the whole, the season under review was favourable. The rainfall was not excessive and there were no long periods of drought, while winds were moderate. All these factors

contributed to the comparative freedom of Dominica from any serious outbreak of pests.

MONTSERRAT. A. The rainfall was somewhat below the average in 1910, but was evenly distributed.

B. The total rainfall at Grove estate was 7 inches less for eleven months than for the corresponding period of 1910. A period of drought extended from May to the latter part of September, when rains fell: good weather was experienced during the months of October and November.

ANTIGUA. A. The rainfall for this period was about 13 inches less than that for the previous similar period; it was, however, fairly evenly distributed.

B. A serious drought prevailed from the end of May, until September. Good rains fell in the later months.

ST. KITTS. A. The rainfall for the first seven months of the year 1910 was very small: only 13 inches was recorded at the Botanic Station. Subsequently, from August 1910 to the end of the period in March 1911, a satisfactory rainfall was experienced.

B. The rainfall, as measured at the Botanic Station, from April 1 to the end of November 1911, was just under 25 inches, the highest rainfall in one month being 4·92 inches in October. The rainfall on the northern side of the island, however, has had about double this value for the same period; 48 inches was received at one estate in this district, and as a consequence, the condition of the crops is more satisfactory in this locality.

NEVIS. A. The rainfall for the year 1910 was below the average; two distinct periods of drought were experienced. During the first three months of 1911 good rains fell.

B. A rather severe drought commenced at the beginning of June 1911, and continued practically until the end of the period, with the exception of the occurrence of a moderate rainfall in September.

VIRGIN ISLANDS. A. The season until mid-August 1910 was abnormally dry. After that, light and intermittent rains fell, favouring the development of the cotton crop.

B. From May 1911 to the end of October, the rainfall was very deficient, and crops suffered greatly from the very hot, dry weather. The hurricane season was exceptionally calm.

TABLES TO SHOW THE OCCURRENCE OF PESTS AND DISEASES OF CROPS IN THE WINDWARD AND LEEWARD ISLANDS.

FOR PERIOD A, JUNE 1910 TO MARCH 1911, AND B, APRIL 1911 TO DECEMBER 1911.

Explanation :—

+	=	positive observation of occurrence.		
o	=	definite	„	„ non-occurrence.
?	=	doubtful	„	„ occurrence.

Where a blank space is left, no reliable information under this head has been received.

INSECT PESTS; PERIOD A.

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
CACAO.									
Thrips		+		+					o
Cacao Beetle									
Scale Insects and Mealy-bugs ...							•		+
Miscellaneous							+		+
CORN (Indian).									
Ear Worm					+	+	+	+	
COTTON.									
Cotton Worm		+			+	+	+	+	+
Boll Worm		+				o			
Cotton Stainers		+			+	+	+	+	+
Scale Insects		+			+	+	+	+	+
Flower-bud Maggot					o	+			
Leaf-blister Mite		+			+	+	+	+	+
Miscellaneous						+	+	+	
GREEN DRESSINGS.									
Leaf-eating Caterpillars		+			+	+	+		
Miscellaneous									
GROUND NUTS.									
Mealy-bugs					+				
Miscellaneous									

INSECT PESTS; PERIOD A.—(*Concluded.*)

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
LIMES AND OTHER CITRUS TREES.									
Scale Insects		+		+	+	+	+	+	+
Bark Borer									
Fruit Fly				+					+
Miscellaneous...									+
ONIONS.									
Caterpillar						+			
Thrips					+	+			
RUBBER.									
Scale Insects		+		+			+		+
SUGAR-CANE.									
Moth Borer		+				+	+	+	+
Weevil Borer		+					+	O	
Root Borer							?		
Cane Fly									
White Ant							+		
Mealy-bug						+			
Miscellaneous...									
SWEET POTATO.									
Caterpillar						+	O		+
Scarabee		+				+	+	O	
Red Spider						+			+
Thrips									+
Miscellaneous...									
MISCELLANEOUS NOTES SUPPLIED.				+	+		+		

INSECT PESTS; PERIOD B.

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
CACAO.									
Thrips	+	+	+	+					
Cacao Beetle	+								
Scale Insects and Mealy-bugs ...	+			+			+	+	+
Miscellaneous	+						+	+	
CORN (Indian).									
Ear Worm	+				+	+	+	+	
COTTON.									
Cotton Worm	+	+	+		+	+	+	+	o
Boll Worm		+				o			
Cotton Stainers	+		+		+	+	o	+	+
Scale Insects	+				+		+	o	+
Flower-bud Maggot					+	+			
Leaf-blister Mite	+	+	+		+	+	+	+	+
Miscellaneous	+				+	+	+	+	+
GREEN DRESSINGS.									
Leaf-eating Caterpillar	+	+			o	+	o		
Miscellaneous...				+					
GROUND NUTS.									
Mealy-bugs					+				
Miscellaneous...									
LIMES AND OTHER CITRUS TREES.									
Scale Insects	+	+	+	+	+	+	+	+	+
Bark Borer									
Fruit Fly									
Miscellaneous...			+		+				
ONIONS.									
Caterpillar					+	+		+	
Thrips									
RUBBER.									
Scale Insects	+	+	o	+	+	+	+	+	+

INSECT PESTS; PERIOD B.—(*Concluded.*)

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
SUGAR-CANE.									
Moth Borer		+	+			+	+	+	
Weevil Borer		+				+	+	o	
Root Borer						+	o		
Cane Fly									
White Ant							+		
Mealy-bug						+			
Miscellaneous						+	+		
SWEET POTATO.									
Caterpillar						+	o		?
Scarabee		+				+		+	
Red Spider						+	+		
Thrips									
MISCELLANEOUS NOTES SUPPLIED.			+			+	+		

FUNGUS DISEASES; PERIOD A.

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
CACAO.									
Root Disease									
Canker		+		+			+		
Die-back and Stem Disease... ...									?
Brown Rot (Pods)		+		+					
Black Rot (Pods)		+		+					
Pink Disease									
Thread Blight									
Horse-hair Blight									
Miscellaneous									
CORN (Indian).									
Root Disease						+	+		
COTTON.									
Anthracnose		+			?			+	
Boll Disease / Angular Leaf Spot / Black Arm		+			+	+	+	+	?
West Indian Leaf Mildew ...		+			+	+	+	o	
Miscellaneous					+		+		
GROUND NUTS.									
Root Disease				o			o	+	
Rust				+	+		+		
Leaf Spot				o					
Miscellaneous									
LIMES AND OTHER CITRUS TREES.									
Root Canker					+	+			
Black Root Disease				+					
Red Root Disease									
Miscellaneous									
ONIONS.									
Bacterial Rot					+		+		

FUNGUS DISEASES; PERIOD A.—(*Concluded.*)

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts.	Nevis	Virgin Islands
RUBBER.									
Para Seedling Disease				+					
Black Root Disease (Castilloa) ...									
SUGAR-CANE.									
Root Disease		+				+	+	+	
Rind Disease		+				+	+		
Red Rot						+			
Miscellaneous									
SWEET POTATO.									
Root Disease						+			
Miscellaneous				+					
YAMS.									
Tuber Disease									
MISCELLANEOUS NOTES SUPPLIED.		+		+			+		

FUNGUS DISEASES; PERIOD B.

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
CACAO.									
Root Disease	+	+	+	+			+		
Canker	+	+	+				+		
Die-back and Stem Disease ...		+	+	+					
Brown Rot (Pods)	+	+		+					
Black Rot (Pods)	+	+	+	+					
Pink Disease			+						
Thread Blight	+		o						
Horse-hair Blight	+		o						
Miscellaneous		+							
CORN (Indian).									
Root Disease						+	+		
COTTON.									
Anthracnose	+	+						o	
Pod Disease / Angular Leaf Spot / Black Arm		+	+		+			+	
West Indian Leaf Mildew		+			+	+	o	o	
Miscellaneous									
GROUND NUTS.									
Root Disease				o	+				
Rust					+				
Leaf Spot									
Miscellaneous	+			+			+		
LIMES AND OTHER CITRUS TREES.									
Root Canker					+	+			
Black Root Disease			+	+					
Red Root Disease				+					
Miscellaneous					+	+			
ONIONS.									
Bacterial Rot									o
RUBBER.									
Para Seedling Disease				o					
Black Root Disease (Castilloa) ...	+		+	+					

FUNGUS DISEASES: PERIOD B.—(*Concluded.*)

	Grenada	St. Vincent	St. Lucia	Dominica	Montserrat	Antigua	St. Kitts	Nevis	Virgin Islands
SUGAR-CANE.									
Root Disease		+	+	+		+	+	+	+
Rind Disease		+	+			+	+		
Red Rot			+			+			
Miscellaneous									
SWEET POTATO.									
Root Disease									
Miscellaneous									
YAMS.									
Tuber Disease			+						
MISCELLANEOUS NOTES SUPPLIED.	+	+	+	+	+	+	+		+

BUD ROT OF THE COCOA-NUT PALM.

BY JAMES BIRCH RORER, A.B., M.A.,

Mycologist, Board of Agriculture, Trinidad.

Bud rot is undoubtedly the most serious disease of the cocoa-nut palm. It has been known for many years, but recently has attracted much attention throughout the West Indies on account of the losses resulting from its ravages and the increased value of cocoa nut properties. Perhaps the most damage has been done in Cuba, where the disease has practically wiped out many of the best cocoa-nut estates; but great loss has also been sustained in some of the other islands and Central American countries as well.

For many years, the cause of the disease was a matter of mere speculation, with the result that it was ascribed by many investigators to poor soil, lack of drainage, and a great number of different insects and fungi. Within the past few years, however, careful studies have been made, and the conclusions reached show that bacteria are the real cause of the trouble and that insects are instrumental only as carriers of infection.

J. R. Johnston, formerly of the United States Department of Agriculture, now Mycologist of the Porto Rico Sugar Planters' Station, has spent several years in the study of bud rot. He has proved by inoculation experiments that the disease is due to a specific bacterium which is so like *Bacillus coli* that the two cannot be distinguished; in fact he states that the disease can be produced by inoculation with pure cultures of *B. coli.* *

The disease gains entrance to the tree as a rule at the bases of the leaves or flower stalks. When the point of first attack is in the outer leaves or older flower stalks, the bud and young leaves may remain unaffected for a long time; but if the infection takes place in one of the central leaves, the bud soon rots and falls over, often leaving some of the nut clusters and outer leaves still attached to the tree. The course of the disease, once it has gained entrance to the tissues, may be either slow or rapid, depending upon many conditions, but in all cases the result is the same; namely, the whole top falls from the tree leaving the naked stem standing.

Whether or not the bacteria can gain entrance to the tissues through the unbroken epidermis, or whether a wound is necessary, I have not been able to make out. However it is possible to infect trees, without wounding them artificially, simply by pouring a pure culture of the causative organism into the crown.

Bud rot must not be confused with the so-called root disease, although both may be present in the same tree. The latter trouble is always characterized by discoloured roots and a distinct red ring of tissue in the stem; while in the case of bud rot pure and simple, the roots and lower stem seem perfectly healthy.

Although Stockdale has attributed the root disease to a species of Diplodia, there is no ground for this assumption. In fact, work which has been carried on here for the past two years points to the conclusion that physiological conditions, rather than any specific organic parasite, are responsible for the trouble.†

Bud rot has been quite prevalent in Trinidad, but measures are being taken to prevent its spread. So far sanitation alone has been used; but the good results have been very marked in that the disease has been greatly reduced. From November 30, 1909, until February 1911, one of the Agricultural Inspectors visited all the districts of the island in which cocoa-nuts are grown, and supervised the destruction of all dead and dying cocoa-nut trees. About 18,000 trees in all were destroyed. The method of procedure has been as follows. Trees which had been dead for a long time were simply felled, cut into junks from 4 to 6 feet long, piled around the stump together with as much trash as possible, and burned. It was found very diffi-

* Since this paper was written, the full account of Johnston's investigations has been issued as Bulletin 228, United States Department of Agriculture, Washington, D. C.

† The details of this work are given in Circular No. 4, Board of Agriculture, Trinidad, 1911.

cult to burn cocoa-nut wood completely, but if it is thoroughly scorched it will serve the purpose as well. In cases where the trees were just beginning to show signs of the disease or had recently died, all infectious material such as the bud, the leaf bases, and flower stalks, and the upper portion of the stems was destroyed at once. This was accomplished by burying the whole mass with lime in deep trenches; the remaining portion of the trunk may be cut up and burned as in the other cases.

Since this work has been done, there has been a marked reduction in the cases of new infections, and it points rather conclusively to the fact that the disease can be held in check by these sanitary measures, provided they are enforced on every property.

We hope soon to be able to make it compulsory for all property owners having diseased cocoa-nut trees to destroy them at once. Our new Plant Protection Ordinance is now before the Legislative Council for its final reading, and will soon be passed.

Although no trials have been made here in spraying cocoa-nut trees, on account of the difficulty ofthe work, some success has been attained in keeping down bud rot by the use of disinfectants placed by hand in the crown of the trees. Salt is the commonest substance used. A pound or two of coarse salt can be tied in a piece of cocoa-nut fibre and suspended in the crown of the tree in such a position that the rains will wash the brine down into the leaf bases. Some planters have tried iron sulphate, and have reported favourably on its use; while still others use copper sulphate.

During the coming year. I hope to try some fungicides and insecticides on a large scale.

In closing, as a note of warning, I should like to say that during the past few years many cocoa-nuts have been planted in Trinidad and other West Indian Islands on soil which is in no way suitable for their growth, and as a result the trees die out when they reach the bearing stage.

Cocoa-nuts will not thrive if they are planted on unsuitable soils and in bush which is simply cut down once or twice a year. The ground must be kept loose and friable by thorough tillage, and the trees given the best possible cultivation.

COCOA-NUT PALM INSECTS IN TRINIDAD.

BY F. W. URICH,

Entomologist, Board of Agriculture, Trinidad.

On the whole, the cocoa-nut palm is fairly free from any serious insect pest; occasionally attacks are isolated and sporadic; many of the insects appear to follow fungus disease or attack trees growing under unfavourable soil conditions; others again are well kept in check by natural enemies, and only increase when these enemies are prevented from doing their work, as will be mentioned later.

BEETLES BORING IN THE STEM. The palm weevil (*Rhynchophorus palmarum*) has always been credited with being most destructive to cocoa-nuts, but with few exceptions is generally a secondary pest, following fungus disease or attacking trees that have been damaged or are growing under unfavourable conditions, and are in consequence weakened. The female beetle appears to be attracted by the acetic fermentation which takes place in diseased trees; further, in most cases that I have observed, it appears to select only trees injured by cuts, cracks or abrasions, for ovipositing. Young trees up to four and five years of age are those mostly attacked. Full-grown trees are not touched. There are several cases on record where apparently healthy trees had been attacked at the growing point and at the base of the developing fronds, but I am inclined to think that there must have been a wound of some kind, either a cracking of the tissues or some other damage. Mr. Dolly, of Mayaro, a most careful observer, has pointed out to me that when young trees are growing in old cultivation, the falling fronds of the tall trees sometimes damage the tender leaves of the small ones and so open the way to a beetle attack. In all cases of attacks on healthy trees I have noticed that the young trees were growing under tall ones. The part of the stem selected is generally the soft tissue near the top and at the bases of the fronds; the larvae sometimes eat into the petiole of the leaf when it is fairly young.

The remedies employed have been preventive, and consist in tarring wounds. If the growing point is attacked, and as long as the bud is not damaged, the larvae are cut out and the wound dressed with tar.

The bearded weevil (*Rhina barbirostris*) has different habits from the preceding species, inasmuch as it attacks full-or half-grown trees. It confines its attack only to the stem. The damage is done by the larvae, which bore regular galleries in the hardest part of the stem, resembling those of longicorn larvae. Like the palm weevil, the bearded weevil is attracted by fermentation, and it is significant that trees suffering from bud rot are attacked at the top, and those affected by root disease at the base, of the stem. The female beetle is not attracted by wounds, but when she lays eggs, she gnaws a little depression in the hard bark of the stem. Besides diseased trees, this weevil will attack trees that have been

scorched either accidentally or 'fired' on purpose to cure disease. Cases of beetles attacking healthy trees that have been scorched have not been observed. The methods of control adopted have been preventive, and consist in tarring the stem of the trees that have been scorched. A mixture of white lime, to which is added 5 lb. of arsenate of lead to every 50 gallons of solution, is also used. Ambrosia beetles (*Xyleborus perforans*) and allied species attack trees under the same conditions as the bearded weevil.

The beetles *Metamasius hemipterus*, *Metamasius cinnamominus** and a species of Rhodobaenus attack trees under much the same conditions as the palm weevil, and are often found associated with it.

INSECTS AFFECTING THE LEAVES. There is quite a number of caterpillars, Coccidae and Aleyrodidae to be found on cocoa-nut leaves, but with one or two exceptions none of them do any damage as they are either not numerous or are kept in check by natural enemies.

The cocoa-nut butterfly (*Brassolis sophorae*) cannot be considered a pest here, but it occurs occasionally wherever cocoa-nuts are grown. A few years ago it was quite numerous in the Naparima district, and destroyed a good many royal palms. It is kept in check by a Tachinid fly.

The following Coccidae have been observed :—

Icerya montserratensis,
Pseudococcus nipae,
Vinsonia stellifera,
Pinnaspis buxi,
Aspidiotus destructor.

The first four species are not numerous, and are kept in check by predaceous beetles and hymenopterous parasites, but the last-named coccid does damage occasionally. It is only injurious to tall, full-grown trees, and then only when associated with the ant *Azteca chartifex*. The ants take great care of the scale insects, sometimes covering them over with a carton made of wood fibre mixed with earth.

Some spraying experiments undertaken have shown that commercial lime-sulphur wash used in the proportion of 1 to 15 will free a tree from ants for six months, and that arsenate of lead in the proportion of 5 lb. to 50 gallons of water acts as a preventive against them. Some trees affected were sprayed with arsenate of lead in November last, and at the time of writing were still free from ants. As long as the ants can be kept away from the trees, the natural enemies of the scale insects get the upper hand. The spraying of tall trees is not quite easy, but it can be done very well by a good cocoa-nut picker. The apparatus used consists of a good barrel pump, 50 feet of $\frac{3}{4}$-inch india-rubber hose, and a rod of about 10 feet. The man ascends the

*In Circular No. 5 of the Board of Agriculture, Trinidad—Preliminary Notes on Some Insects Affecting the Coco-nut Palm—I refer to this species as the Coco-nut Sphenophorus.

tree carrying the rod attached to his belt. Arrived at the crown, he stands up against the stem by means of his climbing loop and does the spraying. About 10 gallons of solution were used per tree. Scales on low trees are controlled by natural enemies, of which there are several species of lady-bird beetles and hymenopterous parasites.

BEETLES AFFECTING YOUNG PLANTS. The insect locally called rhinoceros beetle (*Strategus anachoreta*) is occasionally injurious to young plants by burrowing from beneath into the soft tissues of the plant and destroying the bud. It has never been known to attack a plant above ground. An application of lime around the trees after planting out appears to protect them.

RELATION OF INSECTS TO BUD ROT. The fermenting tissues of a cocoa-nut palm affected by bud rot attract quite a number of insects, but so far no observations of direct transmission of the disease by insects have been made. The palm weevil and bearded weevil have often been mentioned in connexion with bud rot, but they are never found in the rotting bud. The insects more likely to transmit the disease are the scavenger flies whose larvae live in the decomposed bud. Trees affected by bud rot are generally burned or buried.

SCALE INSECTS AND THEIR INSECT PARASITIES.

BY H. A. BALLOU, M.Sc.,

Entomologist on the Staff of the Imperial Department of Agriculture

In 1888, Mr. F. Du Cane Godman, acting on behalf of a Committee for the exploration of the fauna and flora of the West Indian Islands, appointed by a Royal Commission and the Royal Society, sent out Mr. H. H. Smith who spent some timd making collections in St. Vincent, Grenada and the Grenadines. These collections were afterwards studied and reported upon by specialists.

The Parasitic Hymenoptera were submitted to Dr. C. V. Riley, Entomologist to the United States Department of Agriculture. Dr. Riley and two of his assistants who were specialists in this group of insects studied these collections, and reported upon them in two papers, one of which, read before the Linnean Society (London), on June 29, 1893, was entitled A Report upon the Parasitic Hymenoptera of the Island of St. Vincent, by C. V. Riley, W. H. Ashmead and L. O. Howard (*Journal of the Linnean Society*, Vol. XXV, pp. 56-254). The other was entitled A Report on the Parasitic

Hymenoptera of the Island of Grenada, by William H. Ashmead. This was published in the *Proceedings of the Zoological Society* (London), November 19, 1895.

The material from St. Vincent yielded 340 species, and that from Grenada 183. Of these, 303 occurred in St. Vincent but not in Grenada, and 146 occurred in Grenada but not in St. Vincent, and thirty-seven occurred in both islands. From St. Vincent there were 299 species described as new to science, and forty-one which had been previously described. Of the latter, nineteen had been previously recorded as occurring in St. Vincent, and twenty-two were then recorded from that island for the first time. In the material from Grenada, 128 species were described as new and fifty-five were recorded from that island for the first time; this latter number included thirty-seven which had been described shortly before from St. Vincent, in the report already mentioned.

It will be seen from what has been stated that there was an abundance of parasitic insects in the islands where the collections were made: and it is not to be supposed that the material collected by Mr. Smith included more than a small fraction of the species which exist in those islands. The specimens were collected, and not bred from their hosts, and consequently the reports mentioned have not given particulars as to the part played by these parasitic forms in their inter-relations with other insects, and with each other.

A very large proportion of the insects grouped together in the Parasitic Hymenoptera are parasitic in habit; many of them live in the eggs, or the bodies of the larvae or pupae, of plant-feeding insects, while others attack other parasites. A comparatively small number of species in this group are plant feeding.

These insects play an important part in preserving the balance of life, in any given locality; and a knowledge of their habits and their hosts is of value. At the present time, perhaps more than ever in the past, attention is being turned to the possibility of utilizing natural enemies in the fight against pests of all kinds, and remarkable results have been, and are being, attained.

It has long been known that insect pests are generally much more severe in their attacks when introduced into a new locality than they are in their native habitats, and this has been explained by the statement that when they are introduced to a new locality they are not accompanied by their natural enemies.

In California an introduced scale, the cottony cushion scale (*Icerya purchasi*), became a menance to the citrus cultivations of that State, and no remedy or treatment was found which gave satisfactory results in the control of the pest until the Australian lady-bird (*Vedalia cardinalis*) was discovered in Australia, the native home of the cottony cushion scale. This lady-bird was successfully introduced into California in 1889, and since that time has exercised such a complete control over the scale that this insect has practically ceased to be a pest.

In California, also, the black scale (*Saissetia oleae*) is controlled in like manner by means of a parasite (*Scutellista cyanea*) which was introduced from South Africa.

In Florida, scale insects and white fly (*Aleyrodes citri*) are controlled to a fairly satisfactory extent by parasitic fungi. Many other insects besides scales are also controlled by natural enemies.

In the West Indies there are also good examples of the control of insect pests by natural enemies.

In Dominica, the scale insects which occur on limes rarely develop in sufficient numbers to cause serious damage. The internal parasites, the lady-birds, and the parasitic fungi, under normal conditions, exercise a very satisfactory degree of control over them.

The black scale of cotton (*Saissetia nigra*) was a serious pest in Barbados, and to a lesser extent in other cotton growing islands, a few years ago. At the present time, and for several years past, the parasite (*Zalophothrix mirum*) has been sufficiently active to keep this pest entirely within bounds, and the black scale is no longer a pest. The shield scale fungus which is perhaps more abundant, and is certainly better known than formerly, is also of value in this connexion, though not so frequently seen attacking the scale on cotton as on other plants. This has a direct bearing, however, on the relation of the black scale to cotton, since by reducing the numbers of the scale insect on other plants it greatly decreases the rate of infection of the cotton, because the cotton, being an annual crop, must be infested each year from some outside source.

Cotton growers will remember the extreme abundance of the cotton worm in two or three succeeding years, followed by a remarkable absence of this pest for two seasons. This absence was undoubtedly due to the presence of large numbers of natural enemies.

In St. Vincent the natural enemies of the cotton worm have held it in check satisfactorily for the entire eight or nine years since the establishment of the cotton industry.

The natural enemies of the cotton worm are egg parasites of larvae and pupae, predaceous insects, and birds and toads.

The sweet potato worm, the larva of *Protoparce cingulata*, is at times a pest, occurring in such numbers as to be able to defoliate entire fields of potatoes in a few days. Those who have had experience of such an attack probably realize that in the following season the potato worm is scarcely to be found in the same locality. This condition is due to the fact that the dipterous parasite (*Sturmia distincta*) develops in enormous numbers, and attacks such a large proportion of the larvae and pupae, that the progeny of the few emerging moths are hardly to be seen on the succeeding crop.

The moth borer of the sugar-cane (*Diatraea saccharalis*) is known to be held in check to a large extent by the egg parasite *Trichogramma pretiosa*, and it is likely that one or more species of Telenomus are also helpful in this connexion.

The search for these useful forms of insects is being carried on vigorously in all parts of the world. At the last West Indian Agriculture Conference, held in Barbados in January 1908, there was present Mr. W. W. Froggatt, who on behalf of the Government of the States of Australia was making a trip around the world studying the work being done and the results obtained in the control of insect pests by means of natural enemies. Mr. Froggatt's especial interest was in the control of fruit flies. Recently, an officer of the Entomological Bureau of the United States Department of Agriculture has visited India in search of parasites of the citrus white fly. A few years ago Mr. Marlatt of the same Bureau visited China and Japan in search of parasites of the San José scale.

For several years past the Bureau of Entomology of the United states Department of Agriculture, in co-operation with the State of Massachusetts, has been importing parasities of the gipsy moth (*Porthetria dispar*) from Europe and Japan, in the hope of finding some that will become established in spite of the change in climatic conditions, and aid in the control of this most serious pest.

From these few illustrations it will be seen what importance is attached to this line of work. The expense entailed in the importation of natural enemies from foreign countries is enormous, but it is believed that where the efforts are successful the results will amply justify the means, and that chances of success are sufficiently good to warrant a vigorous continuation of the efforts and the expenditure.

An investigation of scale insects and their parasites has been undertaken by the Imperial Department of Agriculture in the West Indies recently in a small way, the object first of all being to ascertain what species of parasites are to be found attacking the scale insects in these islands. Later, the knowledge thus obtained will be available in utilizing the parasites in controlling the pests.

The plan has been briefly this: scale-infested material was to be collected by the agricultural officers in each island and sent by them to the Head Office, where the parasites might be secured for identification.

This work was started in 1909, and for about fifteen months material was received at more or less regular intervals from several of the islands. The leaves and twigs of plants bearing the scale insects were enclosed in muslin or calico bags, and packed in boxes for forwarding by post. Many lots were spoiled by the growth of fungi induced by dampness in the packages, but others were successful.

From this material, eleven species of parasites have been reared and identified. None of these were recorded in the reports noted in the beginning of this paper, while four of the number were new species. The parasite of the black scale of cotton (*Zalophothrix mirum*), which was described as new in 1908, from Barbados, is included among the eleven species secured and as one of the four new species. In addition to this, there have been recently collected and identified nineteen

species of parasites, of which thirteen have been specifically determined. These include two new species.

Parasitic Hymenoptera were collected by sweeping with the net on an experiment plot of limes in Montserrat, in March 1910. An account of this experiment was given in the *West Indian Bulletin*, Vol. XI, p. 39, in an article entitled Notes on Lime Cultivation.

From this collection nine species of parasitic Hymenoptera have been determined, of which five have been identified specifically. One of this number was a new species.

In the case of parasites bred from scale insects the host is known, and of course at least one locality is recorded. Further study may greatly increase the number of known hosts and extend the recognized range of distribution for any of these. The species which were previously known are of general distribution in other parts of the world, while nothing is known yet of the new species except the original record of host and the localities from which they came.

Of the parasitic insects collected by sweeping in Lime Experiment Plot I at Montserrat, the hosts are not known definitely; but from the records of the same species in other localities, and of closely related forms, suggestions as to the nature of the hosts can be made with tolerable accuracy.

In addition to the parasites obtained from the sources mentioned above, there are to be included in this account sixteen others in regard to which more or less definite knowledge is recorded; most of these have been recently identified.

The hymenopterous parasites mentioned in these notes have nearly all been studied by specialists at Washington, D.C., through the kindness of Dr. L. O Howard, Chief of the Bureau of Entomology of the United States Department of Agriculture. A larger part of the identifications have been furnished by Dr. Howard and Mr. J. S. Crawford; the new species have in each instance been described by Mr. Crawford. The writer of this paper desires to express his appreciation of the assistance thus received, and thanks to these gentlemen for their kindness in examining the material

In addition to the parasitic Hymenoptera, other natural enemies of scale insects are known to occur in the West Indies, which may be briefly noted here. These include several lady-birds and the fiery ground beetle, among the Coleoptera, several species of predaceous Hymenoptera, and a few parasitic and predaceous flies among the the Diptera. In this order there are also certain Cecidomyiid flies believed to be parasitic on scale insects and mealy-bugs.

A moth which attacks the Oleander shield scale (*Saissetia oleae*) and a small, reddish mite which is often to be seen associated with scale insects, may be included under the head of miscellaneous natural enemies.

The accompanying tables present in concise form the information relating to the parasites and other natural enemies referred to in these notes.

Insect Parasites and their Habitat.

Parasites.	Hosts.	Food plant.	Remarks.
Hymenoptera	**Scale Insects.**		
Aspidiotiphagus citrinus, Craw.	*Lepidosaphes beckii*	Lime	Very common in Montserrat: a cosmopolitan insect, attacking *L. beckii* on all citrus trees.
	Hemichionaspis minor	Cotton, pigeon pea	Plentiful in Barbados.
Aphelinus fuscipernis, How.	*Hemichionaspis minor*	Cotton, pigeon pea	Barbados.
	Aspidiotus destructor	Avocado pear	Barbados (Coccid B. 6)
Zalophothrix mirum, Craw.	*Saissetia nigra* *S. hemisphaerica* *S. oleae*		Of general occurrence throughout Leeward and Windward Islands.
	Ceroplastes cerripediformis		Principally a parasite of *S. nigra*.
Arrhenophagus chionaspidis Auriv.	*Hemichionaspis minor*	Acalypha	Barbados (B. 12.)
Cocophagus cognatus, How.	*Saissetia nigra* *Hemichionaspis minor*	Hibiscus	Antigua. Twigs bore two species of scales. The host of the parasite is doubtful.
Coccophagus flavoscutellum, Ashm.	*Ceroplastes floridensis*	Mignonette	Antigua (A. 40.)
Coccophagus immaculatus, How.	*Saissetia hemisphaerica*	Teak	St. Vincent.
Coccophagus ochraceus, How.	*Chionaspis citri*	Lime	Montserrat.
Horismenus balloui, Crawford	*Saissetia oleae*	Spathodea	*Z. mirum* was bred from this same scale material and *H. balloui*, and may be a secondary parasite.

INSECT PARASITES AND THEIR HABITAT.—(*Contd.*)

Parasites.	Hosts.	Food plant.	Remarks.
Tetrastichus antiguensis, Craw.	*Ceroplastes floridensis*	Mignonette	Antigua. Bred from same lot of *C. floridensis* as *Coccophagus flavoscutellum.*
Tanaostigmodes tetarus, Craw.	*Saissetia nigra*	Hibiscus	Barbados (B. 7.)

PARASITIC HYMENOPTERA TAKEN BY SWEEPING WITH THE NET IN LIME PLOT I, MONTSERRAT.

Parasites.	Remarks.
Acerota sp.	Family Proctrotiypidae. The species included in this family are largely parasites of Cecidomyiid flies, larvae and pupae.
Chalcis robusta, Cresson	A parasite of the larvae and pupae of butterflies and moths.
Encoila sp.	A genus included in the Cynipidae, a family of gall-making insects. This genus, however, includes parasitic species.
Eurytoma sp.	One of the Chalcidae.
Horismenus nigrocyaneus. Ashmead	A species of Chalcidae, which may prove to be a secondary parasite.
Horismenus sp.	
Perilampus parvus, Howard.	Parasite on Lepidoptera.
Spilochalcis femoratus, Fabr.	Species of this genus are parasites on the eggs, the larvae or pupae of Lepidoptera. One, *S. flavescens* recorded from Tobago, was a secondary parasite on a Tachinid fly which was a primary parasite on the cotton worm. *S. femoratus* has been bred from a Pyralid moth in St. Vincent. (W.H.P., Aug. '09.)
Torymus montserrati	A new species.
Trissodontaspis sp.	A new species.

List of Parasites, with Remarks on Hosts or Supposed Hosts.

Parasites.	Remarks.
Amblyaspis sp.	Taken in Antigua on cotton plants badly infested ' by flower-bud maggot. Believed to be parasitic on *Contarinia gossypii.* This insect has been observed in what was believed to be the act of oviposition in an infested bud.
Amblyaspis verticillatus, Ashmead	Bred from Indian corn, Antigua. Host unknown.
Aphidius sp.	Taken from breeding jar containing wild coffee (*Clerodendron aculeatum*) attacked by Cecidomyiidae, in Antigua.
Apanteles marginiventris	A parasite of lepidopterous larvae and pupae. Bred in Barbados from *Utetheisa ornatrix.*
Chalcis annulata, Fabr.	Parasite of cotton worm and other Lepidoptera, in the West Indies.
Chalcis vestituta, Walker	Reared in Barbados from pupa of cotton worm.
Elachistus sp.	Captured in Antigua, in field of cotton badly attacked by *Contarinia gossypii.*
Encyrtus fusca	Barbados. Probably a parasite of the soft shield scales.
Euplectrus sp.	Captured in Antigua, in field of cotton badly attacked by *Contarinia gossypii.*
Sactogaster rufipes, Ashmead	Reared from material forwarded from Antigua; cotton flower buds attacked by *Contarinia gossypii.* Believed to be a parasite of the flower-bud maggot.
Spilochalcis flavescens, Walker	Reared from pupa of Tachinid parasite of cotton worm. From Tobago.

LIST OF PARASITES, WITH REMARKS ON HOSTS OR SUPPOSED HOSTS.—(*Concluded.*)

Parasites.	Remarks.
Spilochalcis sp.	Bred from *Attacus cynthia.*
Telenomus sp.	Bred from eggs of cotton worm, and from moth eggs found on Cycas, in Barbados. Known also as a parasite of eggs of moth borer.
Tetrastichus hagenowi, Ratz.	Reared from eggs of cockroach (*Periplaneta americana*), Barbados. Probably a secondary parasite.
Trichogromma pretiosa, Riley	Parasite on eggs of many Lepidoptera. A very useful parasite, of wide distribution.
Urogaster leucostigma, Ashmead	Reared in Barbados, from larva of the bean leaf roller (*Eudamus proteus*).
Zatropis denterus, Crawford	Bred from cotton flower buds attacked by *Contarinia gossypii.* This is believed to be the insect, the larva of which has more than once been seen attacking the flower-bud maggot.
Evania laevigata, Latr.	Barbados. Host not known. Other species of the genus are parasites on the eggs of cockroaches.
Ophion bilineatum, Cresson	Barbados. Host not known. Parasites of lepidopterous larvae and pupae.

PREDACEOUS HYMENOPTERA.

Polistes *P. annularis*, Linn. *P. bellicosis*, Cresson *P. fuscatus instabilis*, Sauss.	At least three species of wasps known as cow bees, wild bees and Jack Spaniards are useful aids in the control of insect pests, especially caterpillars. The most active of these is the cow bee (*P. annularis*), which is a valuable natural enemy of the cotton worm in Barbados and St. Vincent.

Parasitic and Predaceous Diptera.

Parasites.	Remarks.
Sturmia distincta, Wied.	One of the Tachinid filies. Recorded as an efficient parasite of the sweet potato worm (*Protoparce cingulata*) in the West Indies. This or another Tachinid is parasitic on the corn ear worm (*Laphygma frugiperda*).
Sarcophaga trivittata, Macq.	One of the flesh flies. Reared from pupae of the cotton moth, and believed to be a true parasite. Barbados.
Syrphus flies	Several species occur ; they attack the larvae of scale insects, plant lice and similar insects.
Cecidomyiid flies	In St. Vincent a Cecidomyiid fly has been bred from the mealy shield scale (*Pulvinaria pyrformis*) on the nutmeg. In Montserrat, a cecid fly has been bred from a mealy-bug on cotton.

Lady-birds and other Predaceous Beetles.

Cycloneda sanguinea, Linn. *Exochomus circumdatus*, Gar. *Exochomus nitidulus*, Fabr. *Megilla maculata* *Pentilia mesilia.* *Scymnus loewii*, Muls. *Scymnus ochroderns*, Muls. *Symnus*, sp.	Lady-bird beetles of the family Coccinellidae occur in all the West Indian islands. They attack plant lice, and the larvae of scale insects and other hymenopterous insects.
Calisoma calidum.	The fiery ground beetle occurs in St. Vincent and Bermuda where it has been recorded as attacking the cotton worm.

MISCELLANEOUS.

The oleander shield scale (*Saissetia oleae*) is often attacked by the larva of a small moth, in several of the West Indian islands. This has not been identified, but may be the same as the species occurring in the United States, which is *Laetilia coccidivora*, Comstock.

A small reddish mite of the genus Chelytus often occurs in abundance on scale-infested plants. It may very easily be distinguished in the dense masses of the orange snow scale, where the contrast of the red colour of the mites with the white of the scales makes them conspicuous.

ZALOPHOTHRIX MIRUM.

The following account of *Zalophothrix mirum*, Crawford, is included as likely to be of interest in connexion with these notes on parasites. This insect is very useful on account of the thorough manner in which it reduces the numbers of the black scale of cotton, and because of its comparatively large size, which enables even casual observers to recognize it with the unaided eye, or at most by the use of a simple magnifying glass.

Zalophothrix mirum is the principal insect parasite of the black scale of cotton in the West Indies Its distribution is very general; it occurs in all the islands from St. Kitts to Grenada, and in addition to the black scale (*Saissetia nigra*) it has also been bred from the brown shield scale (*Saissetia hemisphaerica*), the Oleander scale (*Saissetia oleae*), and from the barnacle wax scale (*Ceroplastes cirripediformis*).

It might be more correct to refer to this insect as an egg predator, for it feeds on the eggs of scale insects. It is not really a scale insect parasite in the strictest sense, since it does not actually live within the body of the scale, feeding on its tissues in the manner of Chalcis, Apanteles and insects of similar habits which are parasites of moths and butterflies. It is not a true egg parasite for the term egg parasite is, in its strict application, used to designate insects such as Trichogramma and Telenomus, which pass the immature stages of their development within the egg of the host.

When the parasite of the black scale was first bred in numbers, specimens were submitted to the United States Department of Agriculture, where Dr. L. O. Howard, Chief of the Bureau of Entomology, kindly arranged to have them studied, and the species named. In a letter to the Imperial Commissioner, Dr. Howard raised the question as to whether there was likely to be any mistake in regard to the observations on the habits of this insect, for he felt that it was much more likely to be an egg parasite than a parasite of scale insects, and suggested that it might be found to attack the egg masses of one of the larger cockroaches. The parasitism of Zalophothrix on the large shield scales was, however, easily demonstrated. It will readily be seen that although the scales are not closely related to the cockroaches, the conditions under which the larvae of the parasite exist are very similar, when attacking

the eggs of the scales, to those under which it would exist if it attacked the eggs in the egg clusters of the cockroach. In either case the larva would live in a confined space, embedded in or surrounded by the eggs which form its food. It will be seen from this that Dr. Howard's assumption as to the nature of the parasitism by this insect proves to be well founded, even though it occurred in a different host from that which he suggested.

The larva of Zalophothrix is to be found under the body of the scale insect, where it lives in an enclosed space in intimate contact with the eggs as they are produced. The eggs of the scale are the food of the Zalophothrix larva, which attains its growth as a larva and passes the pupal stage enclosed in, and protected by, the scale-like body of the adult female scale. The Zalophothrix larva has very little power of locomotion, but is able to move about within its confines sufficiently to obtain its food. This is accomplished by a slow wriggling motion, the actual progression resulting from the pressure exerted upon the adult scale and the plant surface to which it is attached

The egg of Zalophothirx has not been described, nor has the manner of egg-laying on the part of the adult female ever been recorded, and it is probably safe to say that these have never been observed. The assumption may be made, however, that the egg is deposited under the body of the scale insect by the adult female Zalophothrix; but the number of eggs produced by one female is not known, nor is it known whether more than one egg is deposited beneath a scale by the same female. It is rarely that more than one larva is found under a scale, but this sometimes happens. It seems likely that in such a case only one would reach maturity.

The Zalophothrix larva does not appear to attack the body of the parent scale, but the scale insect under which a full-grown larva or a pupa is found is generally dead and dry. This may result from a correlation between the length of time occupied by egg-laying on the part of the scale insect, and the period required by the parasite larva for completion of its development. It may also happen that the latter attacks the body of the scale just previous to entering upon the pupal stage, thus ensuring a dead shell for the adult to penetrate on its emergence.

The larva of Zalophothrix is a maggot-like grub, whitish in colour, with a tendency to pink in the smallest specimens that have been observed. In the older ones the colour becomes a waxy white, somewhat modified by the dark body contents which show through the body walls to some extent. At this stage of its development, the mandibles of the larva may be plainly seen. They are triangular in shape, and light-brown in colour. The full-grown larva measures about $\frac{1}{8}$-inch in length, and is usually found curled up so as to accommodate itself to the narrow confines of the space occupied.

The pupa is formed under the scale in its position on the plant. It lies lengthwise of the scale, its dorsiventral position being the same as that of the scale. When first formed, the

pupa is very light-coloured. It gradually becomes darker, until, just before the adult emerges, it is a deep black. The pupa is naked, that is not enclosed in any cocoon; although in few instances there have been observed fine threads which were thought to have been produced by the parasite, possibly for the purpose of holding the pupa in place. The duration of the pupal stage is fourteen days.

Scales from which parasites have emerged seem to be more firmly attached to the bark on which they occur than the non-parasitized ones, and when such scales are removed they will be found to possess a delicate pellicle which nearly covers the ventral opening. It is thought that this may be produced by the parasite for the double purpose of enclosing its pupal chamber and of holding the scale firmly in place.

At the completion of the pupal period, the adult Zalophothrix emerges by means of a smooth, round hole in the dorsal surface of the scale insect. In the one instance which has been carefully observed the adult freed itself from the pupal skin by breaking this into pieces which separated along the lines of the pupal sutures. In this respect it differs from many insects which, on emerging, leave a pupa case or pupa skin complete, except for the rupture through which the adult has emerged.

The newly emerged adult Zalophothrix is of a light-brown colour. After some hours the colour becomes much darker, until the insect gives the impression to the unaided eye of being black. Examination with a hand lens, however, shows that the general colour is dark-brown, the head being light reddish-brown with prominent dark-brown eyes. There are two pairs of delicate, nearly transparent wings, the first pair of which are crossed near the middle by a broad band of smoky brown; near the base of each of these there is a small patch of the same colour. The wings are generally to be seen laid flat along the back. The length of the adult is from $\frac{1}{12}$- to $\frac{1}{8}$- inch.

No definite information has yet been recorded as to secondary parasitism in the case of this insect, although it is suspected that this occurs. Specimens of the oleander scale on Spathodea received from St. Kitts, yielded three species of parasites, one of these being Zalophothrix, and it is suspected that one or both of the others may have been parasitic upon it. Only one of these has been identified as yet. This was a new species to which the name *Horismenus balloui*, Crawford, was given. In Barbados, another new species *Tanaostigmodes tetarus*, Crawford, was reared in conjunction with Zalophothrix, from black scale on Hibiscus.

The Utilization of Parasitic and Predaceous Insects.

Certain beneficial insects which occur in the West Indies have been mentioned already in this paper, with remarks on their value in controlling the attacks of insect pests. It may be of interest to indicate the manner in which such insects may be made more useful than they are when left to develop and spread under natural conditions. For this purpose a few well-known West Indian pests and parasites are taken as examples.

THE MOTH BORER OF SUGAR-CANE (*Diatraea saccharalis*) AND THE EGG PARASITE (*Trichogramma pretiosa*). One of the methods employed for the control of the moth borer is the collection of the eggs. These are flat, scale-like objects which occur in small groups on the leaves of the canes. They are inconspicuous, but not particularly difficult to find, once the eye is accustomed to their appearance. A large proportion of these eggs is usually attacked by parasites, and the developing larvae contained in them are killed. Eggs containing parasites are darker in colour than healthy ones, and may often be distinguished by this appearance.

When eggs of the moth borer are collected in the field, it is desirable to destroy all those which would produce healthy larvae, and at the same time to allow the development of the parasites until the adults emerge. This can best be done by placing all the collected eggs in a tray or other receptacle near the cane fields. The parasites, as they emerge, are able to fly back into the field in search of moth borer eggs. The moth borer larvae which hatch from the non-parasitized eggs can be prevented from leaving the tray by means of a band of some sticky substance, such as molasses or tanglefoot; or by a trough containing water, so placed that the larvae can get out of the tray only by crawling over or through it.

THE PARASITE (*Zalophothrix mirum*) OF THE BLACK SCALE OF COTTON (*Saissetia nigra*). *Zalophothrix mirum* is very easily introduced into a field where an attack of black scale is being experienced. The method is very simple, consisting merely of collecting twigs of branches of Hibiscus or cotton on which parasitized black scales occur, and tying them among the branches of the plants in which the attack is beginning. As the parasites emerge, they will readily find their way to the scale on the growing plants. Scales from which parasites have emerged are recognized by the presence of the round hole in each, through which the parasite escaped. If non-punctured scales, occurring on the plants where punctured ones are plentiful, are carefully lifted from their positions, on the point of a knife blade, the grubs of the parasites may be discovered beneath.

The adult parasite may be obtained in a few days, if desired for examination or identification, by enclosing a few scale-infested twigs in a glass covered with cloth.

The process of using this parasite is a simple one, and the results are so satisfactory that every planter ought to be ready to employ this means of checking an attack of black scale, in the way that he is ready to apply Paris green to check an attack of the cotton worm.

PARASITES OF THE COTTON WORM. The cotton worm is often attacked by parasites which live inside the larvae and pupae, causing their death. In the event of a severe attack of this pest, it sometimes happens that many caterpillars complete their growth and enter the pupal stage. Some planters destroy these by crushing them, and in this way many parasites are killed. If they are collected instead of being

destroyed, the parasites contained in them might be allowed to live to attack other cotton worms.

This could be done by collecting the cotton worm pupae and placing them in boxes provided with a wire screen which should prevent the escape of any moths which might emerge from non-parasitized pupae, and at the same time allow the parasites to get out and return to the field. (See *Agricultural News*, Vol. VIII, p. 314.) This method of control could only be resorted to when the attack of cotton worms had been fairly severe and there were many pupae to be found. It should be borne in mind, however, that it is not desirable to destroy the pupae, since the parasites would be destroyed also.

THE WILD BEE OR JACK SPANIARD. In St. Vincent a predaceous wasp, the Jack Spaniard (*Polistes annularis*), is known as a valuable natural enemy of the cotton worm; in fact this insect is considered to play a very important part in the control of the cotton worm, which has not yet developed sufficiently to be considered a serious pest.

The Jack Spaniard in Montserrat was not known as an efficient enemy of the cotton worm. It was not the same as the St. Vincent species, and so this latter has been introduced into Montserrat, where it is probably established.

In preparing wasps for shipment it would be necessary only to collect nests in which were a fair number of cells containing pupae, which would be seen to be capped over, while the cells containing eggs and grubs would be open. The nests should be packed in such a manner that they would not be shaken about, and on arrival at their destination they should be hung up in a suitable place. As the pupae complete their transformation the adults will emerge and take charge of the nests, and there should be no difficulty in establishing this insect in new localities in this manner.

PARASITES OF THE SAN JOSE SCALE. The San José scale does not occur in the West Indies, but a brief account of its control by parasites, which are now known to occur in these islands, may be of interest. The San José scale (*Aspidiotus perniciosus*) is one of the most serious scale insect pests ever known. Its common name is derived from the district in California where it first became known as a pest. It is now known to be of Chinese origin, but the exact time and manner of its introduction into the United States have not been discovered.

Professor Comstock in his report as Entomologist to the United States Department of Agriculture for 1880 described this insect as a new species. In 1893 it was discovered in the eastern states. Since that time it has been found in all parts of the United States, and has been distributed to other countries on nursery stock.

The serious injury to fruit trees by this pest caused enormous losses, and as a result the San José scale has received more study than most other pests and the published accounts of its life-history, occurrence, and distribution, together with records of experiments with various insecticides for its control, form a very extensive literature.

Many new washes came into use as a result of the efforts to control this pest, but in California at least, none of these were entirely satisfactory.

During the past twenty years, however, a native parasite (*Aphelinus fuscipennis*) has adapted itself to the San José scale as a host, and at the present time this insect has become one of the insignificant pests where it was the most prominent This condition has largely come about as a result of the parasitism of *Aphelinus fuscipennis.*

In the event of a severe outbreak of this scale in any locality, it is only necessary to procure from a district where the parasites are abundant a few scale-infested twigs, which are hung in the trees on which the scales are increasing, and in a short time the parasites begin to exercise a control over the pest.

This parasite, *Aphelinus fuscipennis*, and another species *Aspidiotiphagus citrinus*, which is an efficient parasite of the San José scale in Japan, both occur in the West Indies.

The use of parasites which at present occur in the West Indies should be neither difficult nor expensive. The importation of the beneficial insects from foreign countries is costly and requires the services of a staff of trained entomologists in order to obtain satisfactory results, and this should not be attempted until the value ef the native insects has been demonstrated. The accumulation of further records as to the hosts and distribution of West Indian insect parasites should place us in a position to deal satisfactorily with certain of our insect pests.

It must not be supposed, however, that natural enemies ever exercise such complete control as to render occasional outbreaks impossible; nor that complete extermination of a pest ever results from the attacks of its natural enemies. Occasional outbreaks will occur, and a few individuals of the host species will always escape even the most severe attacks of parasites. As far as the conditions in the West Indies are concerned, however, an entirely satisfactory degree of control of many pests may be expected. Occasional resort to spraying or other artificial measures may be necessary. In the case of the cotton worm it will be wise for cotton growers always to be prepared to use a poison for the immediate checking of an attack; but at the same time every encouragement should be given to the various natural enemies of insect pests, in order that they may increase as fast as possible and render all the assistance in their power.

SOME FRUIT DISEASES.

BY JAMES BIRCH RORER, A.B., M.A.,

Mycologist, Board of Agriculture, Trinidad.

The fruit industry has advanced so rapidly in the West Indies within recent years that it is not out of place at this time to call attention to a few diseases of fungus origin which must be successfully controlled before the shipping of fruit can be placed on a sound basis. During the past season, many mangoes and avocados have been shipped to the United States and England, and though some have reached their destination in good condition and netted a profit, very many have rotted in transit, and, at times, whole shipments have been lost No doubt a great deal of this loss can be prevented by the selection of good shipping varieties, and the adoption of proper methods of picking and packing; but it does not fall within the scope of this paper to discuss these matters.

Regardless of variety, however, and of care in picking and packing, a great part of the deterioration of these fruits shipped from the West Indies is due to the growth of parasitic fungi. The chief offender in the case of the mango is *Gloeosporium mangiferae*, while with the avocado it is perhaps another species of the same genus.

The disease caused by these fungi is commonly known as anthracnose, or black spot. In each case the fungus attacks not only the fruits in all stages of development but the leaves as well, and in the case of the mango the flowers and flower stalks. The disease on the fruit is quite familiar to everyone. It is first noticed as small dark-brown spots about the size of a pin's head. These rapidly increase in size, and often coalesce until finally the whole surface may become discoloured. When the fruit is sectioned it will be seen that the rot extends right into the seed.

The anthracnose of both the mango and alligator pear can be readily controlled by spraying with Bordeaux mixture, but the work must be very thoroughly done and started in good season. In the case of the mango it is essential that the flowering stalk be protected, so that the first spraying must be done as the trees come into bloom, and successive applications made until the fruit is well set. Later sprayings, when the fruit is half or three quarters grown, must be made, the exact time depending upon the weather conditions.

The time of spraying avocado trees follows that for the mango closely, though perhaps the first applications need not be made so early.

Bananas, in Trinidad at least, are so susceptible to diseases, which as yet cannot be adequately controlled, that they are not planted to any extent save as catch crops and shade plants for young cacao trees.

The two most prevalent troubles are the Panama and Moko diseases. The exact cause of the Panama disease has not as

yet been proved, but the evidence points to a fungus belonging to the genus Fusarium. The Gros Michel variety is especially susceptible to this disease, and cannot be grown in infected soil. The Cavendish and Congo bananas are very resistant to the Panama disease, and the use of these varieties is the only successful way of combating this trouble.

The Moko disease is of bacterial origin, and strange to say, seems to show a preference for those varieties of bananas which are more or less immune to the Panama disease; for example, all varieties of plantains, the Cavendish and red banana are very susceptible, while the Gros Michel, on the other hand, is very resistant.

EXPERIMENTS IN LIME JUICE CONCENTRATION.

BY J. C. MACINTYRE, Dominica.

The experiments in lime juice concentration which are here described were carried out for the purpose of ascertaining the loss of acid occurring at various degrees of concentration so as to be in a position to judge whether the cost of steam-jacketed pans or other plant would be justified, and incidentally, to determine the point to which it is most economical to concentrate.

The experiments were carried out throughout the crop of 1910. The earlier experiments showed marked variations due probably to a variety of causes, but principally (1) to great variation in the quality of the fuel used, resulting in very unequal firing; (2) to the unsatisfactory method adopted for ascertaining the quantities of concentrated juice; and (3) to the impossibility during the pressure of crop of allowing sufficient time for the juice to cool thoroughly before being gauged. Towards the end of the crop it was possible to remedy these defects, and the result of these latter and more accurate experiments, only, are considered. Besides the ordinary boiling house equipment not directly connected with the experiments, the plant consisted of:—

(1) A battery of three copper tayches, two of these being of 150 gallons each, and one of 220 gallons, capacity, the last being farthest from the fire and being the copper from which the concentrated juice was 'struck', 4 to 5 hogsheads being taken at each strike.

(2) A package of 240 gallons capacity, accurately gauged for the measurement of the distilled juice used in the experiments. This was fitted with a lead pipe to conduct the juice direct to the first tayche.

(3) A package of 300 gallons capacity, fitted with a hook gauge for measuring the concentrated juice.

During my earlier experiments a gauging rod was used for ascertaining the quantities of concentrated juice, but this method was found to be unreliable, and measurement by hook gauge was substituted.

As the great accuracy necessary in experiments of this nature is not easy to secure when measuring large quantities of liquid, a brief description of the hook gauge which I used may not be out of place here. My gauge was made somewhat in the form of a surveyor's levelling staff. To the bottom of the sliding rod was fixed a brass picture hook in such a way that the point of the hook, which was filed quite sharp, would point upwards when the gauge was in position. The staff was securely fixed vertically in the measuring vat, the upper part, on which the scale was marked, projecting above the vat. To the upper end of the sliding rod (which was only half the height of the staff) was fixed a piece of sheet brass filed to a chisel edge on the upper side. The scale was carefully adjusted and marked on the staff. The method of using is as follows. When it is desired to measure any liquid in the package, the sliding rod is raised or lowered until the point of the hook just breaks the surface of the liquid and a reading is taken on the scale, on the line indicated by the edge of the brass plate. With this instrument it is possible to get very fine readings, but accuracy obviously depends on the correctness of the scale. To get my scale I first weighed a gallon of clear river water. Into an open oil drum set on a very sensitive scale I poured water to the weight of 5 gallons at a time. Each time the weight was reached the water was run into the vat situated on a lower floor, the rod adjusted, and a line marked on the staff. Precautions were taken to prevent spilling or much disturbance of the surface of the liquid. In this way the 5-gallon divisions were got, the intermediate lines being subsequently put in with the aid of a graduated scale and a pair of dividers.

The scale was a fairly open one, and it was possible to read to $\frac{1}{4}$-gallons. As the quantities to be measured were from 180 gallons upwards, it will be seen that the error of measurement was reduced to a minimum. I subsequently tested the scale in other ways and found it accurate.

I used this gauge for ascertaining the capacity of the vat for measuring the distilled juice used in the experiments. By doing this I further ensured accuracy, as even if the scale on the gauge did not represent the number of gallons indicated, the error would be repeated in the other measuring package—the volumes would be the same in both, and thus the ratios would be correct.

The juice having been distilled and subsided as usual, clear juice was run from the subsiders into a small tank from which it was pumped into the measuring vat, and a sample (50 c.c.) taken, after which the juice was run into the tayches as required. At the end of each day the aggregate sample was measured to secure accuracy of the tally, and tested for acid. Large quantities of juice were used for each experiment, in order as far as possible to reduce the experimental error.

Throughout the work, the juice was run into the copper immediately over the fire, and the strike taken from that

farthest from the fire*. The coppers were always kept quite full** except when striking or when charging up to close an experiment, and I always cooled down for an hour or more before taking a strike. Leakage around the tayches, which is sometimes considerable, did not occur during the progress of these experiments, nor was there any leakage from either of the measuring vats.

The strike was taken direct into the measuring vat and allowed to cool, when the quantity was ascertained and a sample taken after the juice had been thoroughly stirred. The tests for acid were made with the greatest care.

In these later experiments every effort was made to keep the fire as regular as possible and, as will be seen, the results are wonderfully uniform, having regard to the fact that the juice was boiled by direct fire, which is difficult to control.

Assuming a normal loss, the point of economical concentration would be about 9 to 1, which would give 97·6 oz. acid per gallon with a loss of 9·3 per cent. This would be represented by citrometer degree 54 at boiling temperature†.

at 7	to	1	concentration the loss is	6 9 per cent.
" 8	"	1	" " "	7·9 "
" 9	"	1	" " "	9·3 "
" 10	"	1	" " "	11·1 "

1,000 gallons of juice containing 12 oz. of acid per gallon at 7 to 1 concentration would, on the basis of £18 10s. per pipe, represent a net value of £21 3s. 4d., which I arrived at as follows:—

1,000 gal. × 12 oz.	=	12,000	
Less loss 6·9 per cent.	=	828	11,172
Less 4½ per cent. trade allowance‡	...		503
			10,669 oz.

$$\frac{10{,}669 \times £18.\ 10s.}{6{,}912} = £28\ 11s.\ 1d.$$

Charges etc. Discount 2½ per cent., commission 2½ per cent., brokerage 1 per cent., insurance ⅜ per cent., analysis, say, ⅛ per cent.

---

* I wish here to emphasize the importance of striking away from the fire. In a large number of boiling tests carried out by me some years ago when striking from the copper immediately over the fire the average loss at 10 to 1 concentration was 20·3 per cent. This was in addition to acid lost in filter sludge. The system has been discontinued, I believe, on all estates in Dominica.

** Note.—Messrs. Ogston and Moore express the opinion that the loss of acid in concentration is very much greater when the surface level of the juice in the tayches is allowed to sink below flame level, and I think this observation is well founded.

† It is difficult to fix the degree by citrometer with accuracy, as the cooling down for the strike greatly affects the reading.

‡ A trade allowance of 4½ per cent. is made by the analysts in all transactions relating to lime or lemon juice whether in the form of concentrated juice or citrate of lime, and is said to be for organic acids other than citric acid contained in the juice. This does not appear on the account sales.

Total, 6½ per cent.	£1	17s.	1d.			
Freight on 148 gallons at 2½d.	1	9	10			
Dock dues and rents, say, three farthings per gallon		8	11	3	15	10
Net proceeds on a/c sale				24	15	3
Local charges, 5½d. per gallon, made up of :— package 3d. per gallon, export duty 1½d. „ freight, boatage and cartage 1d. per gallon				3	5	7
				£21	9	8

On the same basis 1,000 gallons of juice at

7 to 1 concentration would represent	£ 21	9	8
8 „ 1 „ „ „	21	17	2
9 „ 1 „ „ „	21	19	2
10 „ 1 „ „ „	21	17	0

The average acidity of raw juice, which was tested from day to day throughout the crop, was 12·76 oz. per gallon. The foregoing calculations are based on the acidity of 12 oz., which would allow for acid removed in the sludge, for small mechanical losses occurring between storage tank and coppers, and for transit losses—leakage and soakage.

The correctness of the results obtained was strikingly shown by a comparison of the estimated value of the juice used in the experiments, as calculated on the basis of the foregoing figures, with the amount actually realized by the sale of the produce in London; the difference for the entire crop was under 1 per cent.

It will be seen that the difference in value between concentrations at 8 to 1 and 9 to 1, and between those at 9 to 1 and 10 to 1 amount to less than one-half of 1 per cent. in either case—a difference which is well within the limit of variation in losses in open fire concentration. In my earlier experiments (as well as in those I have conducted in previous years) it was clearly brought out that variations up to 2 per cent. were to be expected between the results of concentrations with very high fire and those with slow fire. Under exceptional circumstances I have recorded losses as low as 4 per cent. at 7·5 to 1 concentration, and as low as 6·5 per cent. at 9·5 to 1 concentration; but in both these cases, as the fire was kept very low, the concentration took nearly twice the time usually occupied in the process, and the juice was allowed to cool thoroughly in the copper before striking.

It follows from the foregoing that the precise point to which concentration is carried is not very material between the limits of 8 to 1 and 10 to 1 concentration, but there would be some advantage in the items of fuel and labour in favour of the lower degree of concentration. Above 10 to 1 the line of loss seems to rise very sharply. Throughout these experiments I took careful note of the acid lost in the sludge removed from the filter bags and ascertained that the loss was about 3 per

cent. of total acid when forty-eight hours had been allowed for thorough draining of the bags, and from 3½ per cent. to 4 per cent. when only twenty-four hours had been allowed for draining. After thorough draining the stuff remaining in the bags is a thick gummy mass, which contains a considerable quantity of acid. Repeated tests have shown that where the clear juice (distilled juice) has tested 14·5 oz. per gallon, the sludge after thorough draining would test from 12 to 12·5 oz. It would be possible to recover most of this acid by washing over a finely perforated sheet metal strainer, but most of the gum would then return to the juice in solution and probably have a prejudicial effect on the quality of the concentrated juice, besides adding appreciably to the quantity of liquid to be evaporated. It could only be satisfactorily dealt with if citrate were being made when neither of the above objections would apply. The total loss of acid then, under conditions of careful supervision, and concentrating to the most economical point, is about 13 per cent.

This on a crop of 10,000 barrels of limes (say, 85,000 gals.) would amount to about £240, with lime juice at £18 10*s.* per pipe. It must be borne in mind, however, that in no process of manufacture is it possible entirely to eliminate loss. The loss of acid in steam concentration in jacketed pans is stated on good authority to be about 3 per cent. at 9 to 1 concentration, to which must be added loss from filters or skimmings—the latter probably amounting to more than the loss from filters. Where filters are used skimming becomes, to a great extent, unnecessary.

In making citrate of lime the loss of acid, Messrs. Ogston and Moore say, should not exceed 2 per cent., and it is possible to recover most of the acid which is lost in filter sludge when concentrating. The chief advantages of citrate-making over the concentration process are:—

(1) A minimum of loss in manufacture.

(2) The relatively higher price usually obtained for the product.*

(3) The great rapidity with which large quantities of juice can be dealt with.

(4) Saving of transit losses.

(5) A saving on the cost of packages, against which, however, must be set the cost of chalk, and when working on a small scale, the somewhat greater cost of manufacture.

---

*Note.—This is not invariably the case. Recently (Oct.-Nov. 1911) citrate has been selling at the price fixed by the Camera, £20 5*s.* while, owing to the difficulty of getting forward supplies from Sicily, the price of concentrated lime juice advanced to £20 12*s.* 6*d.*

LIME JUICE CONCENTRATION EXPERIMENTS.

Juice used (distilled)				Concentrated juice.			Loss in concentration.		Degree of concentration.	Citrometer degree, approximate.*
Gallons.	Test, oz. per gallon.	Acid content, oz.	Equivalent of raw juice at 12 oz. per gall.	Gallons.	Test. ozs. per gall.	Acid content, oz.	Oz.	Per cent. of total acid.		
1.680	14 16	23,788	galls 1.982	275	80·4	22,110	1,678	7 0	7·2 to 1	45
1,680	14·25	23,940	1,995	216 25	89·1	21.940	2.000	8·4	8·1 „ „	50
1,680	13 89	23,335	1,945	221	96 4	21,304	2,031	9 3	8·8 „ „	54
1,680	14·00	23,520	1.960	206·5	103·3	21,332	2,188	10·6	9·5 „ „	58
1,680	13·7	23,016	1,918	195·75	105·1	20,573	2,443	11·6	9·8 „ „	58
1,680	13·57	22,797	1,900	188	107·2	20,153	2,644	11·4	10 1 „ „	60
1,680	14·34	24,091	2,008	197	108·3	21,335	2.756	13·2	10·2 „ „	60
1,690	13·62	22,882	1,907	175	113·5	10.862	3,020	8·7	10·9 „ „	62

* This is only approximate, for when the liquid is being cooled down, before striking, it is not possible to ascertain exactly at what point the strike is made.

Note on Mr. Macintyre's Paper on Experiments in Lime Juice Concentration.

The investigation of the amount of citric acid destroyed in the process of concentrating presents many difficulties and can only be carried on by one having free access to a well-controlled lime juice factory. The results obtained by Mr. Macintyre are, therefore, of particular interest, and are as concordant as may be expected, in view of the difficulties surrounding the work.

2. In order to obtain a uniform basis of comparison, the various lots of lime juice dealt with in the several experiments were reduced to a common basis on the assumption of 12 oz. of citric acid per gallon of juice, and the various degrees of concentration were calculated on that basis. Much of the juice employed for concentration in an ordinary way contains more than 12 oz. of acid per gallon, and this has a bearing on the statement of the degree of concentration; this relationship is shown in the table below.

3. The degree of concentration may also be measured by the quantity of acid in the concentrated juice, and if we take into consideration the loss of acid experienced in concentrating to different degrees, we may correlate this with the rate of concentration in respect of the original juice.

4. In the following table the losses in concentration are taken at convenient approximations based on the results of Mr. Macintyre's determinations, and there is shown (1) the degree of concentration in relation to the raw juice, on the basis (a) of 12 oz. and (b) of 14 oz. of acid per gallon; (2) the approximate loss of citric acid per cent.; and (3) the approximate number of ounces of acid in a gallon of concentrated juice, after allowing for the distribution of acid in concentrating.

Degree of concentration		Approximate loss of acid in concentrating.	Approximate ounces of acid per gallon of concentrated juice.
on basis of 12 oz. per gal.	on basis of 14 oz. per gal.		
7:1	6·0:1	7	78
8:1	6·8:1	8	88
9:1	7·7:1	9·5	98
10:1	8·6:1	11	107
11:1	9·4:1	13·5	114
12:1	10·3:1	16	121
12·5:1	10·7:1	18	123

From this latter it will be seen, for example, that a concentration which Mr. Macintyre refers to as 10 to 1 on the basis of juice containing 12 oz. of acid per gallon is equal to 8·6 to 1 if the juice contains 14 oz. of acid per gallon—a point to be kept in mind in practice.

5. The calculations made by Mr. Macintyre with regard to the effect of the concentration on the charges for packages,

freight, duty, etc., etc., are very important. It is obvious, however, that as some of the charges on shipment are based on the value of the juice, the net value of the product and the gains or losses consequent on concentrating to various degrees will depend upon the market value. The calculations have, therefore, been worked out to show the net value of a quantity of concentrated juice resulting from the concentration of a quantity of raw juice equivalent to 12,000 oz. of acid, when the value of concentrated juice is (a) £18 10*s*. and (b) £15 per pipe, charges deducted as the cost on packing and shipping being based on those given by Mr. Macintyre.

Degree of concentration. Basis 12 oz. per gallon.	Degree of concentration. Basis 14 oz. per gallon.	Acid, oz. per gall. in concentrated juice	Net value* after concentration of 12,000 oz when value of 1 pipe of concentrated juice is £18 10 0	£15 0 0
7:1	6·0:1	78	21 9 2	16 7 3
8:1	6·8·1	88	21 16 6	16 16 10
9:1	7 7:1	98	21 18 1	16 19 10
10:1	8 6:1	107	21 17 7	17 1 0
11:1	9·4:1	114	21 9 11	16 16 0
12 1	10·3·2	121	21 0 11	19 9 10

From the foregoing it is seen that the diminished cost of packages, freight and other charges consequent on higher concentration offsets the loss of acid in such a way that the best financial results are obtained when the concentrated juice has an acid content of approximately 98 oz. per gal. when the market value is £18 10*s*. per pipe, or an acid content of approximately 107 oz. per gal. when the value is £15.

6. For all practical purposes, it appears sufficient to say that the best financial results are obtained, under the conditions laid down by Mr. Macintyre, when the concentration is carried to approximately 100 oz. of acid per gallon,

(Sgd.) FRANCIS WATTS.

*The slight differences between the figures in this column and those given by Mr Macintyre are due to the use of the approximations for loss on concentrating given in the foregoing table.

INVESTIGATIONS ON THE EXTRACTION OF LIME JUICE BY MILLING.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,

Government Analyst for the Leeward Islands,

and

V. M. WEIL, B.Sc.,

Assistant Government Analyst.

The process of extracting lime juice from limes consists essentially of squeezing the fruit in some form of mill, usually of the three-roller type employed in the cane sugar industry, possessing iron or granite rollers, and driven by hand, or by power. It is often supplemented by a cider press in which the squeezed skins are further subjected to pressure in order to extract a further quantity of juice. When the mills are of good type, however, the press is often dispensed with. At the present time ideas regarding the efficacy of the mills employed are generally decidedly vague.

The duty of a mill is usually stated in terms of gallons of juice expressed per barrel of limes. Such a statement leaves something to be desired. In the first place, the size of the barrel is liable to vary to some extent; in the second place, while it is true that the volume occupied by a given weight of limes will remain constant irrespective of size, provided that the limes are uniform in size, on the other hand, individual variation in the size of the limes may induce appreciable variations in the quantity of limes measured. Moreover, the possibility must not be overlooked that the vessels in which the expressed juice is measured may sometimes be considerably in error, in the measurements which they record. Consequently, it is not surprising that at the present time considerable divergence of opinion exists as to the quantity of lime juice which it is possible to express from a barrel of limes by milling.

The problems connected with the extraction of lime juice as practised in the West Indies at the present time are in many ways not dissimilar from those encountered in obtaining the juice from the sugar-cane. In fact, in many cases old cane mills have been adapted to the purpose of expressing lime juice, and so far as the actual extraction is concerned, the processes in the case of the two industries are identical.

In the case of the sugar-cane it is well known that the juice content and fibre content of the cane, as also the saccharine richness of the juice, will depend very largely on the locality in which the cane is produced. Canes grown under dry climatic conditions usually contain less juice and more fibre than canes produced in localities with abundant water-supply. Consequently the simple statement of the amount of juice expressed from a given bulk of canes does not afford an adequate measure of the efficacy of a cane mill, since this will vary with the juice content of the cane.

If the juice content of limes varies with the conditions under which the fruit is produced, in the same way, the mere expression 'gallons of juice obtained per barrel of limes' can only have a local significance, even though the measurement of the quantities were strictly accurate.

As a point of attack for the present investigation, a number of samples of limes were obtained from different localities in Dominica, Montserrat and Antigua, with a view to ascertaining in what way the characteristics of the fruit vary according to the conditions under which it is produced.

In all, ten samples of limes were examined; in each case the average weight and volume of one fruit were first determined. Ten average fruits were then weighed and the juice gently expressed by a hand press; the juice was collected in a tared beaker and weighed separately. The acidity in terms of citric acid, as well as the sp. gr. $\frac{80^\circ}{16{\cdot}6^\circ}$ C. of the expressed juice was determined. On the skins, the acidity in terms of citric acid and the moisture content were determined. From these values the percentage of actual juice present in each sample of limes was calculated. In making this calculation the following formula was used:—

$$\text{Juice content of lime} = x\ (100 - x)\ \frac{a}{b}$$

Where x = percentage by weight of juice extracted
a = acid content of skins, per cent.
b = acid content of juice, per cent.

The acidity was determined by a modification of Prinsen Geerligs's method for the determination of sucrose in megass: it is described in the appendix to this paper.

The results obtained are given in the following table :—

Estate.	Average weight of one lime in grams.	Average volume of one lime in c.c.	Juice per cent. extracted.	Specific gravity of Juice 27°/15°.	Acidity of juice in grms. per 100 c.c.	Moisture, percentage in lime skins.	Acidity, percentage in lime skins.	Juice, percentage in limes.	Specific gravity of one fruit.
Grove, ... Montserrat	61·2	60·6	49·4	1·0342	8·43 (8·15%)	77·3	1·92	61·3	1·099
Isles Bay, ... Montserrat.	51·4	—	50·8	1·0330	8·25 (7·99%)	79·2	1·79	61·8	...
La Haut, ... Dominica.	74·0	74·0	46·0	1·0322	7·19 (6·97%)	80·3	1·85	60·3	1·000
Lisdara .. (ordinary), Dominica.	71·0	70·0	50·6	1·0292	7·39 (7·19%)	83·9	1·53	61·1	1·013
Lisdara ... (spineless), Dominica.	49·0	48·6	50·4	1·0309	8·25 (8·00%)	80·0	1·94	62·1	1·01
Canefield, ... Dominica.	75·3	72·9	48·8	1·0346	8·25 (7·97%)	82·2	2·36	64·0	1·032
Botanic Station, ... Dominica.	64·0	65·0	51·2	1·0327	7·45 (7·21%)	79·4	1·82	63·5	0·984
Dismdale, ... Antigua.	31·3	30·5	38·4	1·0409	8·67 (8·32%)	...	3·19	62·0	1·026
O'Garas, ... Montserrat.	66·6	66·4	46·2	1·0379	8·91 (8·59%)	...	2·64	62·7	1·003

An examination of these results shows that the average weight and volume of a single fruit, as also the acidity of the juice, vary largely according to the locality in which the fruit is grown, the former characteristics varying directly and the latter inversely with the rainfall at the place of origin.

The percentage of juice contained in the fruit, however, varies relatively little, amounting approximately to 62 per cent. of the total weight of the fruit. This result is of a distinctly unexpected character, since comparison with the sugar-cane would tend to the belief that the juice content would be materially less in dry localities. It follows from this that measurement of the extraction of juice, if accurately performed, will afford a reliable criterion of the efficacy of the milling in lime juice works.

From what has been already said, however, the character of measurements of this description often leaves something to be desired; and it appeared that a useful purpose would be served if the endeavour was made to devise some simple system of mill control which could be used as a check on mill work at any time without involving alteration of conditions.

The value of the analysis of megass, in the control of cane mills, prompted the enquiry as to whether equally valuable results can be attained by the analysis of the squeezed lime skins left after the extraction of the juice. In view of the constancy of the juice content of whole limes, the determination of the amount of residual juice left in the squeezed skins appears to constitute a complete check on the efficacy of the milling at the time the sample was taken.

A considerable number of tests on these lines were performed on lime mills in Dominica, Montserrat, and Antigua, with a view to testing the value of the method of control and of ascertaining the efficacy of the mill work in the industry.

The method pursued was to take a sample of expressed skins and of the juice flowing from the mill at the same time; to determine the acidity of the juice and the acidity of the skins, and to calculate the juice lost in 100 lb. of the squeezed skins by means of the formula:—

$$\text{juice lost per 100 lb. of squeezed skins} = \frac{\text{acidity of skins per cent.}}{\text{acidity of juice in lb. per gallon.}}$$

The results are given in the accompanying table :—

No. of mill.		No. of test.	Gallons of juice lost per 100 lb. of skins.
Dominica	1		2·8
	2		2·8
	3		4·3
	4		2·5
	5		2·6
	6		1·8
	7		2·4
	8		2·7
	9		3·3
	10		3·0
Montserrat ...	11	1	2·13
		2	1·99
		3	1·98
		4	2·29
		5	2·40
Antigua	12	1	3·15
		2	8·41

It will be seen that the figures for the amount of juice lost per 100 lb. of skins vary considerably. The best result is obtained in the case of No. 6—a Dominica mill—in which the loss amounted to 1·8 gallons of juice per 100 lb. of skins. This is a cane mill of modern construction, with pressure-regulating apparatus attached.

An interesting series of results is given in the case of mill No. 11, in which a series of tests on five separate occasions indicated losses varying between 1·98 and 2·40 gallons of juice per 100 lb. of skins, and averaging 2·16. The mill in question is one with granite rollers, driven by a 3½ h.p. oil engine. It appears from these results that the minimum amount of juice

lost in this form of milling is somewhere in the region of 1·8 to 2·0 gallons of juice, per 100 lb. of skins. If we regard this minimum loss as unavoidable, the fact remains that in the majority of instances the avoidable loss in milling varies from ½-gallon to over 1 gallon of juice per 100 lb. of skins. If we assume that a barrel of limes gives 80 lb. of pressed skins—an assumption not very far from the truth—we find that the avoidable losses under existing conditions of milling range in the majority of cases from 0·4 to 0·8 gallon of juice per barrel of limes.

It is not at present clear whether, with systematic attention, it might not be possible to reduce the loss sustained under the present system of milling considerably below 1·8 gallons of juice per 100 lb. of skins. If it is not, it seems that the possibility of the maceration of skins with a view to the extraction of the residual juice might be worthy of consideration in the case of plants producing citrate of lime. It is doubtful how far it would be of value in the case of concentrated juice, by reason of the necessity for greatly increased evapcration in consequence of the dilution resulting from maceration.

It seems probable that, when raw juice is being prepared for the purpose of making lime juice cordial, very high pressures are undesirable owing to the amount of pectic matter likely to be introduced into the juice in consequence. When, on the other hand, concentrated juice or citrate of lime is being manufactured, the condition of affairs is different, and it is suggested that careful attention to the milling of limes is likely to be productive of appreciable increases of yield.

The method described in the foregoing pages appears to offer a simple and effective check on the mill work accomplished, and may be recommended as likely to yield useful results, on trial.

APPENDIX.

The following is a description of the method used for the determination of the acidity of the expressed skins.

A quantity of skins amounting to 100 grams is weighed into a tared beaker, 500 c. c. of distilled water is added, and the mixture boiled for twenty-five minutes. The beaker and contents are then cooled to ordinary temperature and weighed. An amount of the solution measuring 100 c.c. is then delivered by means of a pipette into an evaporating basin, diluted with half its volume of water, and titrated against normal sodium hydroxide, using phenol-phthaleïn as indicator.

From the weight of the beaker and contents after boiling are deducted the tare of the former and the weight of the skins employed (100 grams). To this figure is added 80 to allow for dilution consequent on the moisture in the skins, and the result multiplied by the number of cubic centimetres of normal sodium hydroxide used and by 0·00070. This gives the acid content of the skins per cent., in terms of citric acid.

Comparison of the values for the acidity as determined by the above method with determinations on the same samples by the Soxhlet extraction method gave results in close agreement.

SOME ROOT DISEASES OF PERMANENT CROPS IN THE WEST INDIES.

BY F. W. SOUTH, B.A., CANTAB.),

Mycologist on the Staff of the Imperial Department of Agriculture.

For a long time sporadic cases of root diseases on cacao, limes, nutmegs, mangoes, coffee and various other trees of importance either as crops or as wind-breaks have been known to occur in the West Indies. Although this is the case, the identity of the fungi responsible for them has never been determined, and in consequence the actual number of these diseases was a matter of uncertainty. Stockdale, [16] in treating of root disease of cacao, points out that probably more than one fungus is responsible for the disease, even in one island, Dominica; but this remark appears to refer only to diseases included within the category of white root disease as described below. One other disease was known to occur on the roots of cacao and was attributed to *Lasiodiplodia* sp., [16] a fungus now known as *Thyridaria tarda*, Bancroft, which possesses many synonyms, and attacks various parts of a large number of host plants

Very soon after the author's arrival in the West Indies in 1909, specimens of diseased lime roots began to arrive at the Head Office of the Imperial Department of Agriculture in considerable numbers from different localities, and since then diseased roots of all kinds including cacao, limes, Castilloa and immortel (*Erythrina* spp.) have been subjected to examination. As a result, it soon became evident that a disease due to one or a few closely related fungi, probably of the genus Rosellinia, was of fairly common occurrence, particularly on newly cleared estates. This did not appear to have received attention from previous workers. The examination of these specimens was often fraught with considerable difficulty owing to the absence of fructifications of the suspected Rosellinia, as well as to the presence of numerous saprophytic species, since the specimens were often in an advanced stage of decay. An investigation on the spot, in Dominica, in September 1911, gave rise to a much clearer grasp of the situation with regard to this form of disease, and also added another form to the list. Furthermore, a laboratory examination of specimens of lime roots from Montserrat and Antigua, as well as field investigations conducted in Montserrat in March 1910, and in Antigua and Montserrat in July and August 1911, have indicated, that at least one other form of disease occurs in these two islands on lime roots, though in this case the actual cause or causes have not been established. Many points in connexion with the whole question are still obscure and will receive further investigation; but as some of the results are new and of some importance, it is thought that a preliminary account of them may be of interest to the members of this Conference.

In accordance with the foregoing observations, root diseases of permanent crops will be discussed under five heads: white root disease, of which the causative fungus or fungi probably belong to the Hymenomycetes, especially the families Agaricaceae and Polyporaceae, but are otherwise unidentified; Thyridaria root disease due to *Thyridaria tarda*, Bancroft; black root disease due to one or more species of Rosellina; red root disease caused by *Sphaerostilbe* sp.; and lime root canker possibly due to more than one cause, but sometimes associated with *Fomes lucidus* (Leys), Fr. These will now be considered in the order mentioned.

White Root Disease

This disease is sometimes known on cacao as root canker Trees attacked by it may exhibit external symptoms of two kinds. In the first it is seen that the leaves become small and yellowish, while many dry up, and fall off. Then a progressive dying back of the branches commences from their tips, and extends until finally the whole tree dies. In the second, the foliage of a whole tree suddenly wilts and dries up in the space of a day or two. It remains green in colour and hangs on the tree, so that the latter presents a scorched appearance. Within two or three days after this is first observed the whole tree is found to be dry and dead. The difference in these symptoms is not dependent on the causative organism, as both forms may also be observed in cases of black root disease, The form exhibited appears to depend on the rate at which the fungus present rings the collar. Sometimes, especially in dry weather, or when the attack is more particularly confined to the roots, a considerable interval may elapse before the water-supply to the top of the tree is cut off; at others this may occur very rapidly, especially in wet weather, or when the disease spreads up one root straight to the collar. It may be noted here, that the progressive dying back of a tree from its extremities is not an absolutely safe symptom of root disease taken by itself. When it progresses so that the whole tree dies without making any attempt to shoot from its lower portion, the probability of the presence of a root fungus is increased, but careful examination of the roots themselves is necessary in order to arrive at a definite conclusion. When a tree suddenly dries up, root disease is almost certainly the cause, and this can always be confirmed by examining the roots, as before.[14].

When such an examination is made it is seen, in the case of white root disease, that one or more of the main roots is discoloured and decayed. A white superficial mycelium may be present in some instances though it is usually absent. On removing the bark of the older roots and the collar, the mycelium of the fungus may be seen on the surface of the wood, and on the inner surface of the bark. In the early stages of attack it takes the form of star-shaped clusters growing from a common centre, according to Auchinleck's[1] observations, but later it forms fan-shaped masses, and finally produces a continuous sheet between the wood and the bark. This appearance is not distinctive of any definite fungus or group of fungi. Petch[14] describes such a manifestation in the case of

tea killed by an ascomycete *Ustulina Zonata*, Lév., while it also occurs in the case of the black root disease (*Rosellinia* spp) in the West Indies. The white root disease is, however, clearly different from the black, since none of the observers who have described the former have ever mentioned the very distinctive dark-brown strands of superficial mycelium, the dark olive-green covering of mycelium on the base of the stem, or the dark streaks of fungus in the wood, which, as will be seen later, are characteristic of the latter. Marked differences also occur in the mycelial characters of the causative fungus or fungi in the two cases. The symptoms noted above serve as a simple means of separating the two forms of disease. According to Stockdale[16] the typical appearance of mycelium between the bark and the wood is not apparent in the younger roots of cacao, but there is usually a brown discoloration of the inner bark tissues due to gummy substances formed in[1] it as a result of the attack of the hyphae.

The history of the disease is shortly as follows :—

In 1893 Barber[2] described a disease of cacao in Dominica, which possessed the characters detailed above. He recorded its occurrence on cacao, Liberian coffee, mangoes, oranges, pois doux (*Inga laurina*), breadfruit, eddoes, sugar-cane, *Cassia Fistula*, cassava, and bitter orange. He also stated that he had seen a similar disease on cacao and coffee in Jamaica. He believed that the fructification of the caustive fungus was: 'a lateral outgrowth of a mushroom-like character which is usually seen on old trunks of dead trees a few feet from the ground.'

In 1901 Howard[9] published an account of a similar root disease on cacao and nutmegs in Grenada, found during his investigations in 1900. He was able to make a comparison between this form and a specimen of cacao killed by a similar disease in Dominica, and as a result believed the Grenada disease to be possibly the same as that described by Barber. In 1901 he stated, in a report to Sir Daniel Morris, that of certain specimens of fungoid fructifications found on dead cacao trees in Dominica some belonged to the genus Polyporus and others to the group Agaricineae, and he also stated that there is little doubt that the cause of the disease, on one of the estates in Dominica that was referred to by Barber, is a parasitic fungus, or fungi, of the genus Polyporus. In the same year he recorded the occurrence of a root disease of mangoes in Grenada due to a similar fungus to that attacking cacao and nutmegs, but not showing the white sheets of mycelium between the wood and bark.

In 1902 Earle[7] found a white mycelium, usually most developed between the wood and the bark, on the roots of logwood trees in Jamaica, and another similar fungus on cassava growing on land where logwood trees had died in that island. The fungus killed the trees rather slowly. Fructifications of numerous species of Polyporaceae and Thelephoraceae were found on logwood stumps and logs, but none of them could be satisfactorily connected with the mycelium found on the roots; yet Earle believed the latter to belong to the Hymenomycetes.

In 1908 Stockdale[16] published a general account of the root disease of cacao, which he states, occurs in Grenada, Dominica and St. Lucia. He further remarksthat it has been definitely proved that the fungus under consideration may spread from affected roots of pois doux and of breadfruit to cacao and may run down a pois doux wind-break. Dead or dying trees of pois doux, breadfruit, bread nut, mango, pomme rose (*Eugenia Jambos*) and avocado pear had often been observed to occur in the centre of dying patches of cacao, but the connexion was not proved in all these cases. The account he gives of the fungus is different from those of other observers, as he states that the mycelium is first white, then grey, and finally assumes a light-brown colour.

[N.B.—It is evident from investigations conducted in St. Lucia by the writer in April of this year, that is subsequent to the presentation of the paper, that Stockdale's account so far as it applies to that island refers to the black root disease caused by *Rosellinia* sp. and not to the white root disease. Possibly there is some confusion between the two forms in this description. The bread nut, mango, pomme rose and avocado pear are host plants of the black root disease in St. Lucia, and probably the white form was not found on them.]

In 1910 Auchinleck published an account of the form of root disease found in Grenada. His description agrees with Howard's, but he states that it attacks coffee, breadfruit and bananas, as well as cacao and nutmeg.

It is clear, therefore, from this review, that a form of disease which is definitely characterized by the occurrence, in almost all cases, of a white mycelium between the bark and wood of infected plants, exists in Grenada, Dominica, and Jamaica. The disease has been found to attack cacao, coffee, nutmegs, mango, orange (both sweet and sour), logwood, breadfruit, pois doux (*Inga laurina*), *Cassia Fistula*, banana, sugar-cane, eddoes and cassava. It is not certain what or how many fungi are responsible for it. Since its identity is uncertain, little can be said as regards its occurrence in other parts of the world. Howard[9] notes a similar disease in the Cameroons, but this is the only one of which the author is aware, and its possible similarity to the West Indian form is not of much importance in this state of our knowledge.

The mycelium found in connexion with this disease is described as being white throughout, by Howard, Earle and Auchinleck, so that possibly Stockdale's[16] grey and brown forms belonged to the fungus causing black root disease, as recorded in the note above; he does not say whether the change of colour occurred in a pure culture or is only deduced from field observations. Howard[9] found that clamp-connexions occurred on the hyphae of the Grenada fungus, but otherwise there were no distinct characteristics of this mycelium. In Grenada, the disease is more prevalent in heavy wet lands on the heights or near the banks of streams. In Dominica it is believed to spread from decaying forest stumps, as well as from dying wind-belt trees.

The remedial measures consist primarily in removing all

dead trees with as many of their roots as possible and burning them on the infected soil. After this a trench should be dug round the whole affected area in such a way as to include a margin of healthy trees. The trench should be at least 2 feet deep, preferably deeper, and 18 inches to 2 feet wide. The roots of all the trees inside the trench should then be examined, and any trees whose roots are very badly attacked should be dug up and burned. Where the disease is only in an early stage infected roots should be cut off well above the point at which they first appear unhealthy, and then a heavy dressing of quicklime should be stirred in round the roots. If heavy root-pruning is necessary, top pruning should also be carried out to prevent excessive transpiration. After an interval, the infected soil should be well manured and mulched to encourage the growth of the trees. This treatment has been found quite effective. Pois doux is, according to Stockdale [16], rarely attacked by this form of disease and may be used as a wind-belt plant if watched; the other plants recorded above should be avoided. Moreover, when these trees are cut down in cacao plantations their stumps and roots should be dug up and burned.

Finally, it may be noted that white root disease has been separated from the other forms, only because its description, as given by other authors, differs from that of any of the other types. The present writer has not had the opportunity of re-investigating it or of comparing actual specimens with those of the other diseases. Such a comparison is anticipated, but the literature cited appears to afford sufficient justification for the separation.

THYRIDARIA ROOT ROT.

In the year 1894, Prillieux and Delacroix [15] described a root disease of cacao from certain estates in Central America, which they attributed to a fungus called by them *Macrophoma vestita*. This occurred on lowlying lands after they had been flooded. The leaves of affected trees rapidly turned yellow and they and the pods fell off, while within a short space of time the trees died. The bark of the roots was blackened and easily removable, while the wood was of a uniform dark-grey colour. The characteristic pustules, containing the pycnidia now known to belong to the conidial stage of *Thyridaria tarda*, appeared on the surface of the bark. The mycelium of the fungus occurred in the bark and was particularly noticeable in the wood, especially in the medullary rays.

In 1906 Stockdale [16] examined some young specimens of cacao forwarded by Hart from Trinidad, and said to have died of a root disease. He found that a fungus, described by him as Lasiodiplodia was present in the roots. This has since been shown to be the same fungus as that found by Prillieux and Delacroix [8]. (See *West Indian Bulletin*, Vol. X, p. 264.)

In 1909 Griffon and Maublanc [8] described the same fungus again on the roots of cacao from the French Congo, and on those of *Albizzia moluccana* from Madagascar, while they suspected its presence as the cause of a root disease of coffee

growing near dead Albizzia in the same island. In their account they gave a critical discussion of the nomenclature of the fungus and arrived at the name *Lasiodiplodia theobromae* for this and several other forms.

In 1910 Petch [14] published an account of this same disease on tea in Ceylon; he called the causative fungus *Botryodiplodia theobromae.* On tea the fungus usually attacks the young roots first and then passes to the central dead wood of the older roots, so that the bushes are not killed immediately; when, however, the bushes have been pruned, it spreads outwards into the living wood and bark and kills the plants. Death occurs in six weeks to three months after pruning. Petch also found that the fungus could cause die-back of young trees of *Albizzia moluccana*, when they had been pollarded. It spreads down them into their roots and from these passes to the roots of tea bushes in the neighbourhood. It also passes to tea roots in the same way from stumps of Albizzia and from buried tea prunings, as it can spread to the latter from the soil and is able to live vigorously on them. The roots of the tea plants grow in the direction of these buried prunings, because they contain moisture, and thus they become infected. The attack of the same fungus on the roots of young Hevea trees was also recorded by this author. Furthermore, he found that it can act as a wound parasite on dadaps (*Erythrina lithosperma*), allied to the immortel of these islands, and can live on decaying stumps of this species. It is interesting to note that the same or a similar fungus described as *Diplodia vasinfecta* is stated by Watt and Mann [20] to have been found by Butler on the roots of tea in India.

Recent observations have shown that *Thyridaria tarda* occurs as a parasite on the roots of cacao growing in lowlying, ill-drained land in St. Lucia. It is probably only capable of attacking the roots of trees growing in heavy, badly drained soil, and on such would probably appear in any island in the West Indies, since it is present in them all on different host plants. Petch's observations on the disease of tea due to it, suggest that possibly buried heaps of cacao shells might act as a source of infection in the same way as do tea prunings, and for the same reasons; while dead stumps, especially those of immortel, should be viewed with suspicion, as possible sources of infection.

The fungus has been found by Petch [10] as a saprophyte in Ceylon on the roots of coco-nuts killed by *Fomes lucidus.* Stockdale [17] found it in Trinidad on roots of the same host that had died of root disease, while Butler [3] records a similar species on cocoa-nut roots in Travancore. It is reported by Petch [11] to occur on the exposed roots of *Ficus elastica* in Ceylon. Lately it has been found as a saprophyte on young Castilloa killed by black root disease (*Rosellinia* sp.) in Grenada, while the same or a closely related species has been found more than once on roots of lime trees in Dominica, Montserrat and Antigua. It is not certain if the fungus was a saprophyte in all of these cases; in some of them it may have been a wound parasite.

It will be seen that the fungus *Thyridaria tarda* has been treated here only as a parasite or saprophyte on roots. No attempt has been made to trace the complicated history of its synomymy, or to indicate its wide range of host plants, as these matters are out of place in this account.

Remedial measures consist primarily of digging up and burning all dead and dying trees with their main roots. It is doubtful if trenching would be of much service in most cases, as if the fungus is present in a field, it is likely to be fairly wide-spread. If, however, the disease appeared to be spreading from a decaying stump, trenching might be of service, and the stump itself should be destroyed. A point that is of the utmost importance on land where this disease has appeared, is that of drainage. On well-drained soils, it is quite unlikely that this fungus will be able to obtain any serious hold as a root parasite, at any rate on cacao; on wet heavy soils it is almost certain to cause damage, as it is universally present on cacao estates, and there is always enough decaying matter lying about to afford it a start, apart from the heaps of buried shells. The disease is not of much importance on well conducted estates, and in fact occurs so rarely in these islands that exact details as to the time it takes to kill cacao trees and as to its occurrence on stumps and on the commoner trees used for shade and wind-breaks, are not available at the present time.

Black Root Disease.

The symptoms exhibited by the aërial parts of trees attacked by this are very similar to those described for white root disease, that is death may occur comparatively slowly and progressively, particularly in the case of pois doux, or it may be sudden as is more usually the case with limes. When this is so, the tree presents the scorched appearance already described.

On examining the roots, however, it is at once seen that the cause of death is not the same as in the white root disease. The parts affected are one or two, usually not all, of the principal lateral roots, the main root, the collar and the basal one foot of the stem. The surface of the roots and of that part of the collar below ground is covered by numerous brown, fluffy strands of a fungus mycelium often much intermingled with soil. On the larger portions the strands form an almost continuous sheet over the surface of the bark. In very damp situations, or after wet weather, a grey or greenish-grey, cobwebby mycelium may stretch across between the roots, and a similar growth proceeds from the wood of the broken ends of diseased roots, when these are damp after removal from the soil. Round the base of the stem above ground a continuous covering of dark olive-green hyphae is present. The younger hyphae along the advancing edge of this covering are light-grey.

When the mass of brown strands is removed from the roots, the bark beneath is seen to be dark-coloured and dead. It is penetrated by the mycelium of the fungus at definite points; these are usually close together, and a large number occur to the square inch.

The penetrating mycelium may have two forms: it may be wedge-shaped, or may consist of black lines about ½-mm. wide running directly through the bark. The wedge-shaped masses are small, black outside and white below, and are probably of the nature of sclerotia. On the older parts of the roots and on the collar, these sclerotia appear to form an almost continuous sheet with a hard, black, brittle surface lying just below the surface of the bark.

When the mycelium reaches the cambium, it spreads through it and destroys it, and eventually gives rise at each point of entry to fan-shaped white masses of hyphae on the surface of the wood, that are immediately visible when the bark is removed. These masses become closely adpressed and turn pale-brown, grey and finally black in colour when old. The fungus penetrates the wood, and renders it light and often friable. Black streaks of various lengths, resembling those in the bark, run horizontally and vertically, in the wood; and sometimes, at the junction of completely destroyed and less damaged wood, a thin black plate of pseudo-parenchyma is formed, which appears as a thin line, in transverse or longitudinal sections Beneath the advancing edge of the mycelium on the base of the stem, the bark is not attacked, but farther back it presents the same features as does that of the collar below ground.

The dark olive-green covering of mycelium may be present just above the soil-level even before the tree is dead. Very soon after death occurs, it covers the base to a height of one foot or more, and upon it the first, or conidial, fructifications of the fungus are formed. These consist of a large number of short, dark-brown or nearly black stalks that project at right angles to the surface of the mycelium, and, on account of their close crowding and the numbers in which they occur, produce an effect like the pile of a carpet. On these stalks large numbers of small hyaline unicellular conidia arise which give the surface of the fungus covering a light-grey colour. These spores are apparently very readily detached and would be easily carried by wind, so that they form an important means whereby the fungus is distributed. When the tree has been dead for some time the aërial mycelium extends to the lower branches and continues to produce conidial fructifications on its vigorous mature portion, behind the advancing margin. Further back on the old portions, the second or perithecial stage of the fungus is produced. This consists of small spherical black perithecia closely crowded together and surrounded by the remains of the stalks on which the conidia were produced. Their bases are partly immersed in the underlying mycelium, small portions of which may also adhere all over their surfaces. When viewed with the naked eye the perithecia of the form seen in Dominica appear very rough, and resemble black shot with rough surfaces. Inside they contain asci and paraphyses, and in each ascus eight dark-brown, opaque, unicellular, boat-shaped spores are produced. Each spore is sharply acute at either end, and each extremity is produced into a long, straight, or curved, hair-like appendage. The spores, held together by mucilage, are extruded from the perithecia in black tendrils, which emerge through a minute pore at the apex of each

perithecium. This form of fructification is of minor importance in bringing about the spread of the disease, as it is only rarely produced.

The disease is of sporadic occurrence, and is found generally on newly cleared estates or in damp situations. In many instances it is believed to spread from decaying logs, and the continuance of the disease from the roots of a dead mahoe cochon (*Sterculia caribaea*) to those of a lime tree was established in one instance. In another the fungus was found to have killed certain pois doux trees in a wind-belt, and to have spread from them to cacao and lime trees in the neighbourhood. It frequently runs along pois doux wind-breaks, destroying tree after tree, and spreads often to cacao and limes in the neighbourhood. Instances occur in which individual lime and other trees, not near infected plants or decaying logs, are killed by this disease. In this case the attack may have commenced from decaying matter in the soil, especially heaps of dead leaves. It may be recorded that in some instances the disease can clearly be seen to have spread up one of the principal lateral roots, often one whose extremity lay in the direction of previously infected material; but in some cases there is reasonable room for the supposition that the fungus has commenced its attack directly on the collar just below the surface of the ground. In this case the fungus might well have germinated on heaps of dead leaves lying against the stem; its power of living on these would also account for its rapid rate of spread in a wind-break or, as noted in Dominica, along a hedge. It must be stated that the present writer has not noticed it on dead leaves at present, possibly because he was not looking for it particularly in that situation, so that further observations are required to make sure of its presence on them, in the West Indies.

This source of food was, however, noted by Petch[14] in the case of *Rosellinia bothrina*, B. and Br, which causes root disease of tea and of Panax hedges in Ceylon, and he suggests that leaves may also form a starting-point for the fungus. His observations on the subject are as follows: 'It was formerly supposed that Rosellinia originated on Grevillea stumps, but further investigation has shown that the stump rot which spreads from such stumps is rarely Rosellinia. I have seen it on a large Grevillea stump, but in the light of subsequent discoveries its presence there can be explained in another way. I am of opinion that it usually begins in an accumulation of dead leaves; at least that was true of three cases, where the attack has been watched from the beginning. In one case the leaves which had drifted into the base of a Panax hedge afforded it a footing. In another instance, a mango tree was felled, and the log left lying in the tea; in course of time dead leaves accumulated on one side of the log, and from these Rosellinia spread to the tea and the neighbouring Panax hedge. The spores which infected the heaps of dead leaves were no doubt carried by the wind from a patch of tea about 50 yards off, which has harboured Resellinia for some time. It is most probable that in the case of the Grevillea noted above, the fungus originated in the dead leaves around the base of the stump.'

The first step to be taken in dealing with this disease is to destroy all dead or dying trees as soon as they are seen. This should be done at once in order to prevent the formation of fructifications. When it is seen that the conidial stage is already present, it would be advisable to follow a course recommended by Petch[14] in the case of tea in Ceylon. He calls attention to the fact that the handling of trees on which spores are being produced results in scattering these spores into the air, and in the infection of the labourers' clothes. Consequently, before handling the trees he advises that dry straw should be heaped round the bases and over the lower branches of each bush and ignited so that the conidia are burned. This course would be advisable in the West Indies also; any dry material would serve, while in wet districts a gang of men who were about to dig up such trees might carry improvised torches of some kind. All that is necessary is that all conidia should be subjected to a vigorous blaze lasting for a few minutes. In destroying dead trees, care should be taken to dig up as many as possible of their roots. The soil should then be well forked and dressed with lime. The roots of trees in the neighbourhood should be examined, and all those that are infected should be cut off where the tissue is healthy. If several trees have died close together, a trench should be dug round the infected area in the usual manner; while a trench might also serve to arrest the progress of disease in a wind-belt. Such trenches should be kept free from accumulations of leaves.

It does not seem, at present, that any practical measures can be recommended for preventing the occurrence of occasional sporadic cases of this malady due to infection from decaying stumps or heaps of leaves, particularly under the conditions, including heavy rainfall, that obtain on newly cleared estates in the interior of such islands as Dominica and St. Lucia. The prompt destruction of diseased trees may serve to reduce the number of sporadic cases to some extent, by reducing the number of spores of the fungus, but otherwise it is difficult to see what can be done unless all stumps are destroyed—an almost impossible measure in some cases. Attention to drainage is of course important, but is not so absolutely essential in this case as in that of Thyridaria root disease.

It may be stated that it has usually been found, in Dominica that the careful destruction of dead trees, followed by forking of the soil is sufficient to destroy the fungus and that a supply may safely be planted within six months to a year afterwards; the exact length of the interval that should elapse has not been determined.

A fungus presenting the mycelial characters described has been seen to spread from mahoe-cochon to limes, from pois doux to cacao, and from pois doux to cacao and limes in Dominica. The same appearance was also seen on Hibiscus and Acalypha forming a hedge, and is recorded as occurring on unhealthy Castilloa. The conidial stage of a Rosellinia was found on limes, cacao and pois doux, so that this, in connexion with its spread from one to the other, forms a very strong indication of the identical nature of the fungus on these three hosts. The perithecia were only found in two instances on

dead lime trees. Conclusive proof that the disease is due to the same fungus throughout is wanting, in the absence of perithecia on cacao and pois doux, and of inoculation experiments from pure cultures, but the indications supplied by the mycelial characters and the general appearance of infected roots, as well as the spread of mycelium from one host to another, leave practically no doubt that the black root disease in Dominica is due to one fungus.

In St. Lucia, a disease with identical characters also occurs, but in this case there is no absolute proof that the species of Rosellinia is the same as that occurring in Dominica, as no fructifications of the species from St. Lucia have been found. The disease in St. Lucia has been seen by the present writer on the following specimens examined in the laboratory: immortel (*Erythrina velutina*), limes growing near dead immortel and elsewhere, cacao, Castilloa and pigeon pea (*Cajanus indicus*). Here again, there is no absolute proof that the appearances recorded were all due to the same species of fungus, as perithecia were absent, and no inoculation experiments were made: but the indications supplied by the general appearance and nature of the mycelia very strongly support the idea that one fungus only is concerned.

In St. Vincent, a similar mycelium was seen on a dying cacao tree in one locality, while in another young cacao trees were observed which exhibited mycelia, conidiophores and perithecia very like those in Dominica. Unfortunately, the perithecia did not arrive at the laboratory in a very satisfactory condition, so that they were useless for purposes of critical comparison. An interesting point is that these cacao trees were growing on the border of a field of arrowroot attacked by a disease known as 'burning'. This is due to a fungus whose mycelium resembles that of a Rosellinia, and there is a consequent possibility that the arrowroot disease is due to the same fungus as causes black root disease in St. Vincent.

In Grenada, black root disease has been recorded on young Castilloa plants from one locality, and again its mycelial characters suggested that it was due to the fungus found in Dominica. In another locality, a disease was found on an older Castilloa tree which caused a rotting of the bark near the base of the stem. The type of damage inflicted differed in this case from that on the younger trees, but perithecia occurred which were similar in several points to those of the species of Rosellinia found in Dominica, and the nature of the spores was also similar.

Various species of Rosellinia have been found on the roots of plants in other parts of the tropics, and some of these hosts are the same as, or are related to, those on which black root disease has been found in the West Indies; one or two root diseases of uncertain origin, whose symptoms are similar to those of the disease under consideration, also occur in other countries. Among these the following may be mentioned.

In Guadeloupe a disease of coffee and pois doux occurs which is in all probability due to a species of Rosellinia, though

no fructifications of the fungus have been found. It is sometimes associated with the presence of eel worms, but not in all cases according to Delacroix's [5] observations.

In Java a disease with characters resembling those of the Guadeloupe form has been found by Zimmermann [21] on coffee, and Delacroix [5] suggests that it may be due to the same fungus as the Guadeloupe disease. He also suggests that a root disease of coffee in Costa Rica may be due to the same fungus, though Tonduz [18] connects it with *Armillaria mellea.* Delacroix further refers to the record of a similar disease by G. d'Utra [19] in Brazil. There seems to be considerable possibility that the coffee and pois-doux disease in Guadeloupe is of the same origin as the black root disease in the neighbouring island of Dominica.

Watt and Mann [20] recorded a root disease of tea in India that spread from decaying stumps of shade trees. The host plants mentioned are *Machilus* sp., *Melia* sp., *Erythrina* sp., *Bombax* sp., *Mesua* sp. and *Grevillea robusta.* The fungus causing this disease on tea was found by Butler to be a species of Rosellinia related to *R. radiciperda*, Massee. A similar disease of tea in Ceylon was at first attributed to *R. radiciperda*, but Petch [13 & 14] states that the fungus is really *R. bothrina*, (B. and Br.) Sacc. It causes root disease in *Grevillea robusta*, *Symplocos obtusata*, *Panax fruticosum*, *Cinnamomum Camphora*, *Strobilanthes* sp. and dadap (*Erythrina* sp.) It can originate, as described, on heaps of dead leaves and on dead logs. Petch notes that it does not attack cacao or Hevea when growing in infected soil, but suggests that it may have been partly responsible for the extermination of coffee in Ceylon.

Another species, *Rosellinia bunodes* (B. and Br.) Sacc., occurs on coffee in Southern India, according to Petch[13]; while Butler and Sydow[4] state that it is responsible for a disease of pepper (*Piper nigrum*) especially well known in Mysore. The same authors also record this fungus on *Litsea Wightiana*, *Schleichera trijuga*, *Holigarna longifolia* and *Grevillea robusta.* Petch[13] records it as a saprophyte on sticks in a rubbish heap, in Ceylon. This is the species to which the Dominica form appears to approximate most nearly; the local fungus is also similar to *Rosellinia echinata*, Massee[6], found by Ridley on *Ficus dubia*, dicotyledonous shrubs and herbs of many kinds, and on dracaenas and dieffenbachias in an out-of-the-way corner of the Botanic Gardens, Singapore.

The West Indian species has not yet been fully examined, so that a detailed description of the characters of its mycelium and reproductive organs cannot be given at present. It may however be stated that its perithecia and spores appear to approximate very closely to the description given by Petch[13] of *Rosellinia bunodes.*

RED ROOT DISEASE.

In a few instances lime trees growing on newly cleared estates in the interior of Dominica were found to be dying from a disease different from any of those previously described.

A fungus similar to that found on these trees was also observed on the root of an unidentified tree from St. Lucia, where it was associated with the organism causing black root disease. There are no further records of its occurrence in the West Indies at present.

Trees that have died from this malady exhibit the same above-ground symptoms as those that have succumbed to white or black root disease; the appearance of their roots is, however, totally different. The causative fungus seems to commence its attack on the younger roots and spreads up these, usually on one side only, until it reaches the collar. This it girdles, and then it spreads upwards in the bark at the base of the stem. In wet situations it may spread above ground for a height of 1 foot or more; but in drier localities, or in dry weather its growth is checked at the ground level. Here a rough edge of bark having a gnawed appearance is to be seen round the stem, and from its margin adventitious roots arise. It is worthy of note that the same appearance is sometimes caused when the growth of the Rosellinia is checked in the same way.

Roots that have been attacked for some time are devoid of bark, and the wood is dry and blackened. Higher up, the bark still remains but is soft and rotten and discoloured light-brown. Under this bark the surface of the wood is somewhat water-soaked and of a red-brown colour. In the bark and on the surface of the wood long, narrow, red or brown rhizomorphic strands of the fungus may be found, usually running parallel to the axis of the root. From these, hyphae are given off that ramify in all directions through the tissues. On the larger roots, near their junction with the collar, and on the collar itself, the rhizomorphs become wider and branch repeatedly, and ultimately a flat sheet, of a red colour, is formed in the cortex that is partly hidden by the dry outer cortical layers and partly left visible where the outer tissues have fallen away. Sometimes this sheet forms in the place of the cambium layer and is visible when the bark is removed. The sheet itself consists of a continuous red outer skin with white, loosely woven hyphae inside. When the bark is pulled away the upper skin may be removed with it, so that a white sheet is left, having a thin red line along its margin and flecked on the surface with small red patches. This sheet may extend for some distance above-ground on the stem. The youngest portions of the mycelium are colourless, and spread out in a small white fan on the surface of the bark on which the attack is just commencing. Old rhizomorphs are often dark-brown or nearly black in colour. The very fine ones are not easy to see, half buried as they are in the decaying bark of the younger roots, but they may be found on very careful inspection. Below ground, in the angles between the main roots, where there is no earth present, and above ground round the base of the stem, the conidial fructifications of the fungus arise; these spring either from rhizomorphs or the rhizomorphic sheet, or from tufts of white mycelium. They consist of clusters of dark salmon-pink stalks from 2 to 5 mm., approximately, in length, and each surmounted by an opaque white spherical head of spores. When viewed under a low power of the microscope, the stalks are seen to

be slightly hairy, particularly when young. In addition to this Stilbum stage of the fungus, a perithecial stage was found in one instance. The perithecia are minute, red, flasked-shaped bodies, the neck of the flask being often somewhat curved and about as long as the diameter of the lower spherical portion of the organ. They occurred in groups, and in this instance were seated on a rhizomorph. Each contains asci and paraphyses. In the ascus eight, bicellular, somewhat reddish-yellow transparent spores are formed, arranged obliquely in a single row. The spores are bluntly pointed at either end, constricted at the septum, somewhat thick-walled, and measure approximately 17-20 × 8·5-10 Microns. They germinated very readily in about four hours, and in culture media gave rise to rhizomorphs and Stilbum fructifications resembling those found on the lime trees. In cultures, a third form of fructification appears of the Cephalosporium type, the spores formed on the short conidiophores being very similar to those borne in the head at the summit of the stalk or stroma.

Inoculation experiments have not yet been conducted with this fungus, though there is little doubt of its facultative parasitism. Its method of spread has not been clearly made out. There is a belief prevalent in the island that all root diseases of this sporadic nature arise from decaying stumps, but several instances of this disease were noted on trees that were not growing near decaying wood. The specific identity of this fungus is also not certain, though it undoubtedly belongs to the genus Sphaerostilbe, of which it may be a new species. It is necessary to obtain a fresh supply of perithecia before this point can be settled, as only very few of these were found in the first instance.

The only other recorded species of Sphaerostilbe acting as a root parasite, of which the writer is aware, is *S. repens*, B. and Br., found by Petch [12] on Hevea and arrowroot in Ceylon. This differs from the West Indian species, particularly in the shape of the perithecia, and in the nature of the conidiferous hyphae at the apex of the stroma, as well as in the attachment of the spores to these. In *S. repens* the conidiferous hyphae are septate and bear the conidia on short blunt processes one below each septum; they are unbranched in the upper 200 Microns. In the West Indian species, the end of the conidiferous hyphae is non-septate for a considerable length, and tapers to a blunt point to which the conidium is attached. Below the first septum one or more usually non-septate branches, similar to the end of parent hyphae, arise and bend round so as to lie nearly parallel to the parent: each of these produces a conidium at its tip. A short distance farther back another transverse septum occurs, and behind this another branch is given off, which may be once or twice septate, and bears a conidium at its tip.

Further details of the characters of the local species must be reserved for the present.

The remedial measures to be employed against this disease are similar to those reccommended for black root disease, but they cannot be given in full until more is known of the habits and distribution of the causative fungus.

Root Canker.

This is a disease that has been found to occur on lime trees in Montserrat, and possibly also in Antigua. It is not quite certain if only one disease is included under this heading or not.

The above-ground symptoms are the same in Antigua and Montserrat. Infected trees show a yellowing and drying up of the leaves on a few of the twigs. These may be situated either at the top of the tree or on one side; usually the symptoms are limited at first to a few twigs. Soon after this the leaves fall off and the twigs upon which they were growing dry up. The drying progresses slowly backwards until the whole of a principal branch is affected and the tree shows the presence of a considerable amount of dead wood either at the top or at one side. When the disease has caused the death of a principal branch, or even before, it may be arrested in its progress, and recovery or partial recovery may take place. More frequently, however, it continues its advance; other branches dry up, and finally the tree dies. The time occupied from the first appearance of the disease until the death of the tree seems to be from twelve to eighteen months in the majority of cases, and as much as twenty-four months in some instances; that is when it progresses continuously. When the tree partly recovers, it may survive in varying conditions of moderate or ill health for several years.

It may be noted that these symptoms are similar to those caused by scale insects, especially the purple scale (*Lepidosaphes beckii*), but in several cases they appeared on trees not attacked by scale insects for some time previously.

On removing the soil around such trees the first point noted is the almost complete absence of fibrous roots, which are usually very numerous in the soil around healthy trees. This is a fairly constant sign of the presence of root canker. The younger branches of the root system to which the fibrous rootlets are attached show scars at the old points of attachment, and may also show distinct symptoms of the disease.

The infection frequently spreads back along them until a root of a higher order is reached. At this point it may be arrested, or it may spread further until the collar of the tree becomes affected. When the tree is dead on one side only, usually not more than two or three of the primary roots are involved and then they generally lie beneath the dead branches. The death of the tree is due to its becoming completely ringed at the collar.

The first sign of disease on the larger roots is the occurrence of small patches, over which the bark is somewhat frayed and watery in appearance. This bark dries up and disappears, so that open wounds result, which extend down to the wood. In some instances the damaged tissue runs backwards right along a root to its junction with the stem or with a root of a higher order. In these cases it frequently occurs as a strip varing from $\frac{1}{4}$- to 1 inch in width, running along the root. The older parts of this strip show an

open wound extending down to the wood and bordered by a distinct callus; farther back the bark is dry and frayed for a distance of a foot or more, while at the margin of the disease it has a water-soaked appearance. Long strips of the frayed bark come away very easily if gently pulled at the frayed end.

Where a secondary or tertiary root meets one of a higher order, the spread of the disease is frequently arrested, and a circle of callus is formed round the point of junction. Sometimes, also, the attack does not progress far at first and only covers 1 or 2 inches of bark here and there on the roots. Its spread in this case is soon stopped and a ring of callus is formed round the diseased spot; in consequence of this a cankered patch is produced.

In serious cases, the whole of the bark on many of the roots, including some of the main roots, is destroyed, and the wood is exposed and dries up; it then, frequently, has a somewhat blackened surface, though inside it is dry and white. The frayed bark shows the presence of colourless or brown hyphae, when examined under the microscope, as well as of eel worms in the dead tissue. Similar brown hyphae may be seen on the surface of the bark, and inside the tissues of the fibrous roots, where the disease appears to originate. In several instances a white, somewhat waxy-looking mycelium was found between the drying bark and the wood of trees examined in the field. The wood presented a dry, brownish appearance beneath the mycelium and was somewhat powdery on the surface, though inside it was firm and white. The internal tissues of dead roots devoid of bark may contain large, septate, colourless hyphae. The black appearance of their surfaces is of secondary origin and only occurs when the roots have been dead some time. Besides the waxy mycelium mentioned above, threads of white mycelium have been observed in a few instances running from a cankered patch along the surface of the bark.

The full detail of these root symptoms applies to trees in Montserrat; those of the disease in Antigua are similar, though they have not been so thoroughly investigated.

The manner in which the disease spreads from tree to tree over an ever-increasing area suggests that it is due to a definite parasite, as do also its sudden appearance in healthy fields, the symptoms observed on the roots and the presence of a fungoid mycelium in the damaged tissues. Two fungi have been found on dead or dying trees. The first, an unidentified species belonging to the Sphaeriaceae, occurs on the dead, dry branches where it forms a hard stroma beneath the bark, upon which numerous, partly erumpent perithecia are produced. The wood is discoloured grey where the mycelium penetrates it. The fungus occurs not only on older trees but also upon supplies of about one year old that are in a dead or dying condition. Its presence on dead branches renders it probable that it is only a saprophyte, and is not responsible for the root symptoms.

The second fungus is *Fomes lucidus*, (Leys.) Fr. The fructifications of this species have been found frequently on the basal

1 or 2 feet of the stems of dead or dying trees, both in Antigua and Montserrat. Petch[10] has found this fungus to be the probable cause of root disease of coco-nuts in Ceylon, as well as of mango and flamboyante (*Poinciana regia*); while it is associated with some other palms and with bamboos, and occurs as a saprophyte on several trees.

The fructification or sporophore is usually produced, on lime trees, from a distinct cushion of white superficial mycelium on one side of the tree. It possesses a lateral stalk, which may be as much as 4 inches long, or may be reduced to a broad basal tubercle, so that the fructification itself appears as a bracket. When the stalk is present, it is usually more or less erect, irregularly cylindrical in shape, polished on the surface, and of a colour varying from bright chestnut to almost black. The apex of the stalk is at first white and conical, but later it grows out on one side into a broad cap or pileus, which thus comes to be attached to the stalk at the margin. The upper surface of the cap is yellowish-red, reddish-chestnut, deep red or almost black; it is polished like the stalk and usually marked with concentric furrows. When the sporophore is immature the margin is swollen, white and fibrous, and is not polished, while the varnished portion immediately behind it is then yellow, and the colour slowly deepens into that of the main part of the cap. The lower surface is white and contains the tubes bearing the brown spores, which are ejected as a dust of the same colour. The substance of the sporophore is brown and fibrous. Several caps may fuse together during growth and then their outline becomes irregular. Single caps are usually circular or kidney-shaped when stalked, and semicircular when the stalk is reduced; they vary in size from a diameter of 2 or 3 inches and a thickness of ½-inch, to a diameter of 20 or more inches and a thickness of 4 inches.

It would appear to be fairly certain that the ultimate destruction of the roots is due to a fungus, either *Fomes lucidus* or some other, or possibly even to more than one species. The question, however, still remains whether the roots are first weakened and some even killed by other causes such as the destruction of the branches by scale insects, and whether it is only after this that the fungus can gain a hold and destroy them; or whether the fungus is the primary and principal cause of the disease. In considering this question, two points must be borne in mind. The first is that attacks of the purple scale rarely result in the complete death of the tree; and the second, that in several instances, as is stated above, trees showing much dead wood and unhealthy roots were not, and had not been for some time, seriously attacked by scale insects; in fact only a few such could be found upon them. These points would indicate that the fungus is more likely to be the true cause of the disease, though the damage is undoubtedly often aggravated by attacks of scale insects. In some instances the trees appear to be able to overcome the inroads of the disease and show marked recovery, and it would seem that their ultimate fate depends largely on such factors as the occurrence or non-occurrence of periods of drought and of attacks of scale insects.

Our knowledge of this disease will be seen to be in a very preliminary stage, and further investigations will be carried out at an early date. The problem presented is somewhat complex, and until it has approached nearer to a solution, little can be done in the way of recommending remedial measures for its control. It may be noted that a disease possessing somewhat similar symptoms in certain respects, though with differences, has been found in one instance in Dominica, and that the balance of the evidence in this case points to its being attributable to physical causes.

This, then, is the present position of knowledge with regard to root diseases of some of the permanent crops and shade trees of the West Indies. It is still of a very preliminary nature, but it is hoped that what has been set forth here, may serve as a starting point for further investigations.

References.

1. Auchinleck, G. G. Root Diseases of Cacao in Grenada. Proceedings of the Agricultural and Commercial Society, Grenada, Nov. 18, 1910, Appendix 2, pp. 159 and 160.
2. Barber, A. C. Report on Failure of Cacao crop in Dominica, 1892-3. Supplement to the *Leeward Islands Gazette*, April 27, 1893, p. 52.
3. Butler, E. J. Report on Coco-nut Palm Disease in Travancore. Bull. 9, Agricultural Research Institute, Pusa, pp. 9-11.
4. Butler, E. J. and Sydow, H. and P. Fungi Indiae Orientalis. *Annales Mycologici*, Vol. IX, p. 404.
5. Delacroix, G. Les maladies de Plantes Cultivées dans Les Pays Chauds. *L'Agriculture Pratique des Pays Chauds*, 1907, pp. 329-33 and p. 416.
6. Fungi Exotici, III, *Kew Bulletin*, 1901, p. 155.
7. Earle, F. S. Diseases of Logwood, Cocoa-nut, Cassava, etc. at Jamaica, *West Indian Bulletin*, Vol. IV, pp. 2 and 8, reproduced from the *Journal of the New York Botanical Garden*, Vol. IV, pp. 1-10.
8. Griffon and Maublanc. Sur une maladie du Cacaoyer. *Bulletin de la Société Mycologique de France*, Vol. XXV, 1909, pp. 51-8.

Also Maublanc. Les Maladies des Plantes Cultivées dans les Pays Chauds. *L'Agriculture Pratique des Pays Chauds*. 1909, pp. 318-24.

9. Howard, A. The Fungoid Diseases of Cacao in the West Indies. *West Indian Bulletin*, Vol. II, p. 207.

10. Petch, T. Root Disease of the Coco-nut Palm. *Circulars and Agricultural Journal of the Royal Botanic Gardens*, Ceylon. Vol. IV, No. 24.

11. „ „ On Lasiodiplodia. *Annals of the Royal Botanic Gardens*, Peradeniya, Vol. IV, pp. 445-65.

12. „ „ Physiology and Diseases of *Hevea brasiliensis*, p. 192, and a Root Disease of Hevea. *Circulars and Agricultural Journal of the Royal Botanic Gardens*, Ceylon, Vol. V, No. 8.

13. Petch, T. Revisions of Ceylon Fungi, II. *Annals of the Royal Botanic Gardens*, Peradeniya, Vol. IV, pp. 433 and 434.

14. „ „ Root Diseases of Tea. *Circulars and Agricultural Journal of the Royal Botanic Gardens*, Ceylon, Vol. V, No. II.

15. Prillieux and Delacroix. Sur Quelques Champignons Nouveaux ou peu Connus Parasites sur les Plantes Cultivées. *Bulletin de la Société Mycologique de France*, Vol. X, p. 165.

16. Stockdale, F.A. Fungus Diseases of Cacao and Sanitation of Cacao Orchards. *West Indian Bulletin*, Vol. IX, pp. 167-70 and 177.

17. „ Fungus Diseases of Cocoa-nuts in the West Indies. *West Indian Bulletin*, Vol. IX, pp. 363 and 364.

18. Tonduz. A. El blanco o moho de las raices del capeto. *Boletin del Instituto Fisico-geografico de Costa Rica*, 1900.

19. d'Utra. G. O mofo ou fungo das raizes, *Boletin da Agricultura* (Estado de Sao Paulo), 1901, No. 8.

20. Watt and Mann. The Pests and Blights of the Tea Plant. Second edition 1903, pp. 411 and 414.

21. Zimmermann, A. Over eene wortelschimmel van *Coffea arabica*, *Teysmannia*, Batavia, 1901.

ADDENDUM.

Subsequent to the presentation of this paper, specimens of the Rosellinia from Dominica were forwarded to the Royal Botanic Gardens, Kew, and through the courtesy of the Director were examined by E. M. Wakefield and determined as *R. bunodes* (B. and Br.) Sacc. In making this identification Wakefield writes: 'Compared with the type from Ceylon, the spores are very slightly larger, measuring 85 - 90 × 10 - 12 Microns, without the appendages, while those of the type average 80 - 90 × 9·5 - 11 Microns. In other respects it agrees exactly, and is to be regarded as the same species.' Petch (Revisions of Ceylon Fungi, Part II, *Annals of the Royal Botanic Gardens*,

Peradeniya, Vol. IV, p. 434) gives the spore measurements as 80 - 110 × 7 - 12 Microns.

A comparison of the Dominica specimens with fructifications on old Castilloa plants from Grenada shows that the same fungus also occurs in the latter island; it has recently been found there on young camphor plants also. An investigation of the St. Lucia disease has shown that it is due to a different species of Rosellinia, of which only immature perithecia have been found. (See Report on the Rossellinia Root Disease of Cacao in St. Lucia. Circulars dealing with Plant Pests and Diseases, No. 2, of this Department.)

NOTES ON EXPRESSED AND DISTILLED WEST INDIAN LIME OILS.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S., and N. GREENHALGH, B.Sc.

The lime, like the fruits of other members of the Citrus family, contains essential oil in vacuoles situated immediately beneath the outer rind or skin. Two classes of lime oils are at present known to commerce: (1) the hand-expressed oil or otto of limes; (2) the distilled oil.

Hand-expressed oil is obtained by rapidly rotating the fruit round the interior of a copper bowl termed an écuelle pan, the inner surface of which is covered with projecting brass points. The oil cells become punctured and the oil, mixed with a certain amount of watery fluid from the skins, runs down into a little well at the bottom of the pan; it is subsequently separated from the underlying layer of watery fluid, filtered, and stored in vessels ready for export.

The distilled oil, on the other hand, is obtained by performing the first stage of the evaporation of raw lime juice, in the manufacture of concentrated juice, in a copper still and condensing the distillation product; the steam passing over carries with it the more volatile portion of the oil, which is collected in a form of the well-known Florentine flask.

It may be pointed out that the distilled oil is derived from the rind in the same way as the hand-expressed oil, the oil cells becoming ruptured in the process of milling, and the oil running down with the juice.

It is a characteristic of distilled oils, in contrast to the écuelled product, that they possess a somewhat unpleasant, acrid smell, and their value is in consequence very much lower. This is due to the abstraction of the non-volatile constituents, together with a certain amount of decomposition arising from the high temperature.

The comparative paucity of information concerning the characteristics, chemical and physical, of hand-expressed lime oil (or otto of limes), as well as of the distilled oil of limes, prompted the collection of a number of samples from Dominica and Montserrat for purposes of examination in the Government Laboratory, Antigua.

The following data concerning the characters of West Indian lime oils are abstracted from Gildemeister and Hoffmann's work *The Volatile Oils*, Messrs. Schimmel's *Semi-Annual Report*, and Allen's *Commercial Organic Analysis*, 1907, Vol. II, Part III.

HAND-EXPRESSED OIL. This oil is of a golden-yellow colour, and is hardly distinguishable from a good lemon oil by its odour. The most important constituent is citral. It contains also a paraffin, limonene and methyl anthranilate and 10 to 18 per cent. of non-volatile residue. The oil gives a cloudy solution in 4 to 10 vols. of 90 per cent. alcohol with separation of wax or paraffin-like constituents,

Density at 15°C. 0·878 to 0·901, mostly between 0·880 and 0·884
Rotation + 32° 50′ to + 37° 30′ (Schimmel, October 1909)
+ 35° to + 38° (Gildemeister and Hoffmann)
+ 36° to 40° (Allen)
Rotation of the first 10 per cent. of the distillate rather higher, or at most 4 per cent. lower, than that of the original oil.
Refractive index at 20°C. 1·482 to 1·486
Acid number up to 3·0
Ester number 18 to 3·0

DISTILLED OIL. Distilled oil has an unpleasant odour, like turpentine or pine tar oil, and no longer reminds one of citral. Probably this aldehyde is completely destroyed by the boiling of the acid liquid. The oil boils between 175° and 220°. Residue on evaporation 3 per cent.

Density 0·865 to 0·868 (Gildemeister and Hoffmann temp. not given)
Rotation + 38° 52′ „
+ 46° 36′ (Schimmel, October 1904)

For the purpose of this investigation, seven samples of expressed oil and three samples of distilled oil were obtained; these are identified by letters as follows :—

A.	Hand-expressed	oil,		Antigua.
B.	„	„	„	„
C.	Hand-expressed	oil,		Montserrat.
D.	„	„	„	„
E.	„	„	„	„
F.	„	„	„	Dominica
G.	„	„	„	„
H.	Distilled	oil,		Dominica
I.	„	„		„
J.	„	„		„

With the exception of samples A and B, which were produced on the same estate but at different times, the remaining samples of expressed oil and distilled oil were produced on estates at different points in Montserrat and Dominica. In

every case there is no doubt as to the authenticity of the samples, which are all of recent origin.

On each of the above samples was determined

(1) The specific gravity at 30° C.
(2) The optical rotation in a 100-mm. tube (at 31° C.)
(3) The refractive index (at 32° C.)
(4) The citral content by Burgess and Child's method.
(5) The acid value, by titration of 5 c.c. of the oil dissolved in alcohol, with $\frac{N}{2}$ alcoholic potash in the cold.

The results are given in tabular form below:—

Sample.	Specific Gravity at 30°C.	Rotation in angular degrees at 31° C.	Refractivity at 32° C.	Citral, per cent.	Acid No.
Expressed oils.					
A.		31·38	1·4851	6·6	2·8
B.	·8859	31·63	1·4836	5·2	2·7
C.	·8752	32·11	1·4816	5·2	2·6
D.	·8712	32·80	1·4809	2·4	1·6
E.	·8740	32·67	1·4815	4·0	2·04
F.	·8664	33·43	1·4789	2·4	1·35
G.	·8659	32·04	1·4789	2·2	1 44
Distilled oils.					
H.	·8540	34·30	1·4713	2·0	1·3
I.	·8858	34·89	1·4702	1·4	0·76
J.	·8567	33·09	1·4712	1·2	1·1

With regard to the hand-expressed oils, an examination of the results shows a somewhat wider divergence between the character of the different oils than that indicated by figures given by the various authorities already quoted, although they are in general agreement with them. The figures for the optical rotation are somewhat lower than one would expect; this is probably partly accounted for by the expansion of the oil owing to the high temperature at which its measurements were made; possibly also the specific rotation of the optically active constituents may tend to decrease with rise of temperature.

The citral content and the acid number vary markedly in the different samples: it is interesting to note that a fairly close correlation appears to exist between the two figures; subsequent investigation, however, appears to lend some colour to the view that the relatively high acidity recorded in the case of these oils with a relatively high citral content may possibly have been due in part to interaction between the aldehyde and alcoholic potash used for the titration.

The citral determination by Burgess's method seems to give satisfactory results, and the appearance of a marked line of demarcation between the oil and underlying sodium sulphate solution would appear to indicate the absence of citronellal.

The citral content as determined in this way varies markedly in different samples.

On the whole, the citral content of the hand-expressed oil is lower than is the case with lemon oils, which according to Gildemeister and Hoffman contain 7 to 10 per cent. of that constituent.

With regard to the distilled oils, samples I and J came from the same estates as samples F and G; no corresponding sample of expressed oil was obtained from the estate supplying the sample H. The samples appeared to be characterized, on the whole, by a lower refractive index, citral content, acid number, and in the case of H and I, a lower specific gravity. The rotation, on the other hand, is in all cases somewhat higher.

To obtain a certain amount of further information regarding the different bodies of which the oil is made up, a sample of hand-expressed oil was subjected to fractional distillation.

The original samples were taken from sample G, and 100 c.c. taken for the distillation.

The temperature, and corresponding approximate volume of oil distilled and refractive indices of each of the fractions, are given below:—

Fraction.	Temperature.			Approximate volume, c.c.	Refractive index at 28°C.
1			155° C	20	1·4705
2	155°	to	169°		1·4708
3	169°	„	171°		1·4711
4	171°	..	3	50	1·4708
5	173°	„	5		1·4709
6	175°	„	7		1·4711
7	177°	„	9	20	1·4713
8	179°	„	182°		1·4719
9	182°	„	186°		1·4721
10	186°	„	190°		1·4737
11	190°	„	195°		1 4742
12*	195°	„	200°		1·4736
13†	200°	„	235°		1·4890
14	Tarry		residue	10	

(Refractive index of original oil = 1·4770 at 32°C.)

* Bluish liquid.

† Blue liquid filtered from crystals (see below).

As is seen from the above the greater portion of the oil distilled over between 171° and 177°C. It appears that this fraction consists largely of limonine or closely related bodies. At 200°C. decomposition set in and the distillate became slightly blue, the contents of the flask turning dark-green. As the temperature rose a deep-blue oil distilled over, and the green colour of the liquid in the flask became more intense. At 235°C. the vapour was also coloured and the distillation was discontinued. About 10 c.c. of a tarry-brown liquid remained, which on cooling solidified to a hard, vitreous, black mass.

The blue fraction on standing deposited pale-yellow crystals leaving a deep green motherliquor. These were separated, dried and crystallized several times from chloroform. A very light, faintly yellow substance was obtained, crystallizing in fine needles and having the melting point at 131·5° C. Its nitrogen content was determined and found to be 11·16 per cent.

One hundred cubic centimetres of distilled oil from the same estate was next subjected to fractional distillation in the same way :—

Fraction.	Temperature.	Approximate volume, c.c.
1	175°C	15
2	175° to 8	60
3	178° „ 182°	
4	182° „ 6	
5	186° „ 205°	20
6	205° „ 245°	
7	Residue	5

As 200°C. was reached, signs of decomposition were evident : the distillate became green and this colour was intensified as the temperture rose. A few cubic centimetres of a deep-green liquid were left in the flask. No change was observed in this on standing, and no crystals were deposited.

For purposes of comparison, a steam distillation was performed on about 75 c.c. of expressed oil (d). This gave a perfectly clear oil with the characteristic terebinthinate distilled oil odour. The portion remaining undistilled consisted of a heavy, opaque, greenish oil, which retained in a modified form the odour of the original oil. The distillate was subsequently fractionated and the following fractions were collected :—

Fraction.	Temperature.	Approximate volume, per cent.
1	170°C.	19
2	170° to 2°	30
3	172° „ 5°	25
4	175° „ 180°	15
5	180° „ 235°	9
6	Residue	2

Decomposition set in about 185°C., and a small quantity of a golden-yellow oil remained undistilled in the flask.

From the above results, it would appear that during the process of distillation with steam (the conditions under which ordinary distilled oil is obtained being practically those of a steam distillation) a certain proportion of the lower- and higher-boiling constituents are removed. The blue fluorescence due to the presence of a crystalline substance in the higher fractions of the expressed oil is entirely absent in those of the distilled oils. This substance possibly may be the methyl anthranilate which is known to exist in lime oil (Allen), to the methyl ester of which—$C_6H_4(NH.CH_3).COOCH_3$—E. J. Parry ascribes the blue fluorescence of mandarin orange oil (Allen's *Organic Analysis*, 1907, Vol. II, Part III, p 40.) This is probably removed during the steam distillation.

Expressed oil on standing generally deposits a pale-yellow crystalline substance known as limettin. Distilled oils do not deposit this body. Limettin is stated to be dimethoxy-coumarin; it is readily soluble in hot water, and it is possible that distillation with steam effects the removal of the limettin itself, or of that constituent of expressed oils which by the action of light may be converted into limettin. (A sample of limettin recrystallized from boiling water was found to have a melting point of 115°C.)

The proportion of citral is also less in distilled oils than in the corresponding expressed oil, owing probably, to some chemical change brought about during the distillation.

These, then, are some of the possible causes of the marked difference between expressed and distilled oils. At present, however, our knowledge of the constituents of the oils is far too meagre for us to be able to explain fully the nature of the changes taking place during the steam distillation of an expressed oil.

THE LIME INDUSTRY OF ANTIGUA.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,
Superintendent of Agriculture for the Leeward Islands.
and
T. JACKSON,
Curator of the Botanic Station, Antigua.

Limes have been cultivated to some small extent for many years in Antigua, but until the last few years the total trade in the products of the industry have been but small.

During the past few years, however, interest in the crop has very considerably increased, and large extensions of the area planted have been made.

At the present time there are approximately 500 acres under the crop, and of this probably not more than 200 acres are bearing.

The values of exports of lime products during the past nine years have been as follows :—

1900-1	...	...	£267
1901-2	...	...	£194
1902-3	...	...	£221
1903-4	...	...	£342
1904-5	...	...	£290
1905-6	...	...	£501
1906-7	...	...	£542
1907-8	...	...	£1,223
1908-9	...	...	£951
1909-10	...	...	£2,269
1910-11	...	...	£1,636

The exports have included raw and concentrated lime juice, green and pickled limes, and hand-expressed lime oil. It is interesting to observe the marked increase in the value of the exports during the past five years.

A point of some significance, which indicates the amount of interest now being taken in this form of cultivation, is that during the past year, 1911, the number of lime plants distributed from the Botanic Station exceeded the total distribution during the entire period 1901-9.

The number of lime plants distributed in each year since 1900 is shown in the following table :—

1900-1	...	...	1,510
1901-2	...	...	5,323
1902-3	...	...	434
1903-4	...	...	1,430
1904-5	...	...	501
1905-6	...	...	1,700
1906-7	...	...	800
1907-8	...	...	8,800
1908-9	...	...	3,650
1909-10	...	...	10,585
1910-11	...	...	16,150

At present the work of raising lime seedlings constitutes an important branch of the station work. So great has been the demand during the past year for plants that the Botanic Station has been taxed to its utmost to meet requirements, and this has in consequence necessitated the construction of new nursery plots. This was in part due to the severe drought prevalent during the earlier part of the year, the situation of the old lime nursery being such as to render the supplying of water difficult.

The areas in Antigua which may be regarded as the most suitable for growing limes are situated in the south of the island. Here, the soils are of volcanic origin, and light and deep, and the rainfall is more abundant than in other districts. It is in this part of the island that the greater part of the planting is now being carried on; though areas have also been established on the limestone soils in the northern and eastern parts of the island, where the rainfall is much lower.

While the conditions obtaining cannot be regarded as ideally suited to lime-growing, nevertheless the success so far attained by the older plantations prompts the hope that the prospects may be favourable for these more recently established.

So far, no very serious attacks by pests or diseases have befallen the industry. Scale insects are everywhere prevalent, but they appear to be held in check to a considerable extent by natural enemies.

THE ACID CONTENT OF LIME FRUITS.

BY G. A. JONES,

Assistant Curator, Dominica.

A short time ago, there appeared in the *Agricultural News* (see Vol. IX, p. 260) a brief account of the results obtained from investigations that had been undertaken at the Dominica Botanic Station with the purpose of ascertaining the circumstances upon which the acid content of lime fruits depends. These investigations have been continued, and it may serve a useful purpose to place before the members of the Conference the results of the additional work that has been done.

The acid content of lime fruits varies between 10 and 16 oz. of citric acid per gallon. These are outside figures; a variation of between 12 and 14 oz. per gallon is, however, quite common on different estates in Dominica. This variation may be due to several causes, some of which are known and some unknown. Probably the chief factor in causing variation is rainfall. Estates showing rainfall returns between 16 and 27 inches, for a period of five months preceding the date of testing, had an acid content of 14·1 to 14·8 oz. per gallon; other estates, having a rainfall between 29 and 39 inches for the same period, showed tests of 13 to 13·8 oz. per gallon; and finally those with a rainfall between 42 and 72 inches produced fruits testing between 12·4 and 12·8 oz. per gallon. Few Dominica estates have a higher rainfall than this, even during the rainy season. One estate received a precipitation of over 143 inches in five months; another a rainfall of 110 inches for the same period, but the fruits tested from both these estates were not abnormally low in acid content: the first gave 12·5 and the second 12·7 oz. per gallon. Whether the comparatively high acid test was due to a dry period experienced during the last three weeks of the five months, or whether when a certain limit is reached, provided that the soil is well drained and of an open texture, the rainfall does not further affect the acid content, has not yet been made evident to the writer. We almost think that the latter is the correct explanation, but further investigations will have to be undertaken before any definite statement can be made on this point.

Closely connected with the variation due to rainfall is the variation which we find in the acid content of large limes as compared with that of the smaller fruits. Generally speaking, the more abundant the rainfall, the more vigorous is the growth of the trees, and consequently the greater is the production of fruit. The fruit is also distinctly larger in the wetter districts. It is found, however, that the acid contents of the larger fruits are distinctly lower than that of the smaller fruits growing under the same conditions of rainfall; in one case a difference amounting to as much as 1·1 oz. was recorded.

Another factor that seems to have a distinct bearing upon the acidity of lime fruits is the condition of the soil with

regard to its water-content and retaining power. The soils in the North Windward districts of Dominica are quite distinct from those on the Leeward coast. The former are often red, retentive soils; the latter open and pervious. During a period of five months, the rainfall on two of the Windward coast estates averaged 46·6 inches, while that on the Leeward coast averaged 54 inches. The acid tests of the fruit coming from the latter, however, were distinctly higher than that of those from the former one. Further, a sample of juice extracted from fruits growing on a particularly dry part of a red retentive soil gave an acid test 1·1 oz. of citric acid higher than a sample taken from the same field, in a less thoroughly drained portion. This point has been well brought out owing to the dry period already referred to.

Investigations have also led to the conclusion that lime trees, as they attain maturity, produce fruits of a higher acid content. Juice tested a few years ago, from trees growing in the interior of Dominica, showed a distinctly lower acid test than they do now; and again, we have tested young and old trees growing under identical conditions, with results in all cases in favour of the latter, varying from over 1 oz. to 0·6 oz. per gallon of juice.

There are at least two distinct varieties of limes growing in Dominica: the ordinary variety with spines, and the spineless variety. Of the several advantages claimed for the spineless variety, the most important are its high acid content and the purity of its juice. Juice extracted from fruits of the spineless variety was tested by Dr. Francis Watts in 1906, and found to contain over 16 oz. of critic acid to the gallon, as compared with 14 oz. contained in the ordinary variety growing under similar conditions. Repeated testing has always brought out the superiority of the spineless variety in this respect, when these are grown in the Botanic Station; but on changing the locality, for example for an estate in the hills or on the Windward Coast, this marked superiority appears to become lost. Samples of limes of both varieties, grown in the country districts, have been tested, but the results were practically identical. This was rather unlooked for, and leads one to suspect that the increased acidity of the juice from the spineless limes is not a fixed character, but that it is affected by certain definite conditions.

Finally, there exists a distinct variation in the acid content of fruits from individual lime trees when growing under identical conditions. This is naturally to be expected; but whether or not the increased acidity is a constant character remains an open question. It appears to be constant as far as individual trees are concerned. The trees in the spineless plot in the Botanic Station have been individually tested at three different periods of the year. The two giving the highest tests in the first observations came out first in both the second and third testings, though they varied like all the other trees with the season. One of the best trees tested 15·3 oz. to the gallon in December 1909; 16·2 in May 1910; and 14·8 in October 1910. Budwood has been taken from this tree and budded on to sour orange stocks; the plants thus obtained will

be grown for trial, and in due course the fruits will be tested. The results will be watched with interest. Chemical selection in the case of the lime is quite new, and some interesting results may be possible.

Briefly, these are some of the conditions and circumstances which, no doubt together with others, account for the variation which is known to exist in the acid content of lime fruits.

It may now be of some advantage to point out the economic importance of the investigations.

A pipe of citric acid is now quoted at £18 10*s.*; 1 oz. of citric acid is therefore worth slightly over 0·64*d.*, on the London market. In Dominica, to-day, with the London prices at £18 10*s.* per pipe, 5*d.* per gallon is paid for raw lime juice containing 12·4 oz of citric acid to the gallon. Packages are supplied, and the juice will be removed from the estate at the price quoted. At 5*d.* per gallon of 12·4 oz. citric acid, 1 oz. of citric acid is worth 0·4*d.* If, therefore, for some cause or other one estate produces raw lime juice containing, say, 1 oz. of citric acid per gallon more than another, and assuming that both estates give a yield of 100 barrels of limes to the acre per annum, and that both estates extract 8 gallons of juice per barrel, the first estate produces 800 oz. of citric acid per acre more than the other. Valued at London prices, this increase is worth £2 2*s.* 8*d.* per acre, and at local prices, £1 6*s.* 8*d.* per acre. Assuming again that each estate has a cultivation of 50 acres, the respective increase at London prices and local prices for the estate with the richer yields would be £106 5*s.* and £66 5*s.*

As we have shown, the acid content of the lime fruits from different estates may vary as much as 2 or 3 oz. per gallon; such a difference is of a very considerable monetary importance.

Several other investigations with regard to the lime juice industry are being undertaken in Dominica by the Department and others; time and patience are necessary in carrying them to a successful conclusion. Special reference may be made to the crushing experiments. A few of our planters held, and still hold, the opinion that it does not pay to extract more than 7½, or at the most 8, gallons of juice per barrel, the argument being that the remaining gallon or more contains so little acid that it does not pay the cost of handling. As far as the experiments go—and they will be continued—they do not support the above statement. In one trial, a planter obtained 9 gallons and 8 gallons, respectively, of juice per barrel. Separate samples were tested and the test showed no difference. As we did not actually witness the operation of the crushing, in this case, we decided, in co operation with another planter, to carry out a similar experiment. In this case 8¼ gallons and 9 gallons were extracted, respectively. The juice from the lower extraction tested 13·3 oz. per gallon, and from the higher 12·8 oz. per gallon. On calculation, this shows an advantage for the higher extraction of 5 oz. per barrel, which would almost cover the cost of picking the limes. Until further experiments are carried out, the safest course to follow is to arrange the mill so as to obtain the highest possible extraction.

OBSERVATIONS ON THE DEVELOPMENT OF THE WEST INDIAN LIME FRUIT.

BY A. J. BROOKS,

Assistant Agricultural Superintendent, St. Lucia.

These observations were made for the purpose of ascertaining the exact length of time taken from the flowering period to the maturity of the fruit, and to see if the spineless lime differs from the spiny or ordinary lime in this respect.

Individual lime trees growing in the field under ordinary conditions were selected for the purpose of observation, care being taken to choose those trees most sheltered from strong winds and other conditions, which would be calculated to affect the results.

Twenty-four flower buds of the ordinary lime, and a similar number of those of the spineless variety, were placed under daily observation as soon as they were large enough to be seen by the unaided eye, and records were made of the length of time required for the petals to fall naturally.

Ten flowers of the ordinary lime, and three of the spineless, set and developed fruit. Careful measurements were then taken at regular intervals during the development of these fruits until their natural fall. The first measurement was taken exactly one month after the fall of the petals.

The average size, in diameter, of the ordinary lime fruit was then $\frac{11}{16}$-inch and the spineless $\frac{9}{16}$-inch.

Table A shows the rate of growth every fourteen days, which is somewhat remarkable for its uniformity, irrespective of wet and dry periods.

It is generally supposed that a period of five months is necessary for the fruit of the lime to reach maturity, but upon reference to Table B, it will be seen that only sixteen and a half weeks were required, for the ordinary lime, and nineteen and a half, for the spineless variety, to reach that stage.

TABLE A.

Dates.	Measurements of fruits, diameter in inches. Ordinary limes. Nos. 1	2	3	4	5	6	7	8	9	10	Average diameter, inches.	Measurement of fruits in inches. Spineless. 1	2	3	Average diameter, inches.
June 18	$\frac{8}{16}$	$\frac{13}{16}$	$\frac{10}{16}$	$\frac{14}{16}$	$\frac{10}{16}$	$\frac{12}{16}$	$\frac{12}{16}$	$\frac{13}{16}$	$\frac{10}{16}$	$\frac{11}{16}$	$\frac{11}{16}$	$\frac{10}{16}$	$\frac{9}{16}$	$\frac{9}{16}$	$\frac{9}{16}$
July 2	$\frac{15}{16}$	$1\frac{2}{16}$	$1\frac{1}{16}$	$1\frac{4}{16}$	$\frac{15}{16}$	$1\frac{2}{16}$	$1\frac{1}{16}$	$1\frac{2}{16}$	1	1	$1\frac{1}{16}$	$1\frac{1}{16}$	$\frac{15}{16}$	$\frac{15}{16}$	$\frac{15}{16}$
„ 16	$1\frac{5}{16}$	$1\frac{7}{16}$	$1\frac{3}{16}$	$1\frac{9}{16}$	$1\frac{3}{16}$	$1\frac{6}{16}$	$1\frac{5}{16}$	$1\frac{4}{16}$	$1\frac{2}{16}$	$1\frac{3}{16}$	$1\frac{4}{16}$	$1\frac{6}{16}$	$1\frac{4}{16}$	$1\frac{5}{16}$	$1\frac{5}{16}$
„ 30	$1\frac{7}{16}$	$1\frac{9}{16}$	$1\frac{5}{16}$	$1\frac{9}{16}$	$1\frac{5}{16}$	$1\frac{8}{16}$	$1\frac{8}{16}$	$1\frac{6}{16}$	$1\frac{5}{16}$	$1\frac{5}{16}$	$1\frac{6}{16}$	$1\frac{7}{16}$	$1\frac{5}{16}$	$1\frac{6}{16}$	$1\frac{6}{16}$
Aug. 13	$1\frac{7}{16}$	$1\frac{9}{16}$	$1\frac{6}{16}$	$1\frac{9}{16}$	$1\frac{6}{16}$	$1\frac{8}{16}$	$1\frac{9}{16}$	$1\frac{9}{16}$	$1\frac{7}{16}$	$1\frac{6}{16}$	$1\frac{7}{16}$	$1\frac{7}{16}$	$1\frac{5}{16}$	$1\frac{7}{16}$	$1\frac{6}{16}$
„ 27	$1\frac{7}{16}$	Fell Aug. 21	Fell Aug. 21	Fell Aug. 23	$1\frac{8}{16}$	$1\frac{10}{16}$	Fell Aug. 23	Fell Aug. 15	$1\frac{8}{16}$	$1\frac{9}{16}$	$1\frac{8}{16}$	$1\frac{10}{16}$	$1\frac{7}{16}$	$1\frac{9}{16}$	$1\frac{8}{16}$
Sept. 10	Fell Spt. 10				$1\frac{9}{16}$	$1\frac{12}{16}$			$1\frac{10}{16}$	$1\frac{11}{16}$	$1\frac{10}{16}$	$1\frac{12}{16}$	$1\frac{7}{16}$	$1\frac{11}{16}$	$1\frac{10}{16}$
„ 24					$1\frac{11}{16}$	Fell Spt. 16			$1\frac{12}{16}$	$1\frac{11}{16}$	$1\frac{11}{16}$	Fell Spt. 24	Fell Spt. 23	Fell Oct. 3	
Oct. 8					Fell Oct. 3				Fell Spt. 26	Fell Spt. 28					

TABLE B.

Number of buds under observation.	Date upon which first petals opened.	Date upon which last petals fell.	Number of days in flower.	Ready for picking as green limes.	Natural fall of ripe limes.		Average time taken from fall of petals to fall of ripe fruit.
					Commenced.	Finished.	
24 spiny	May 4	May 18	14	Aug. 7 to 14	Aug. 21	Oct. 3	16½ weeks
24 spineless	„ „	„ 14	10	Aug. 9 to 16	Sept. 23	„ „	19½ „

OUTLINE OF MANURIAL EXPERIMENTS ON COCOA-NUTS IN TRINIDAD AND TOBAGO.

BY J. DE VERTEUIL, F.C.S.,

Assistant Analyst, Government Laboratory, Trinidad.

Manurial experiments are being made on two coco-nut estates in Trinidad, and on one estate in Tobago. These experiments are under the control of the Board of Agriculture.

The manures are supplied free of cost to the proprietors, but the cost of application as well as the cost of general cultivation are borne by the estate owners.

There are eight plots on each estate, two of which were only forked and no manures applied. These are kept as control plots.

The following experiments are being made:—

	Manures applied per tree.	Cost of manures per tree (landed in Port-of-Spain).
		$ c.
1	4 lb. lime 4 „ kainit	4·86
2	6 „ basic slag 1 „ sulphate of potash	7·23
3	4 „ basic slag 2 „ nitrate of soda	7·68
4	2 „ calcium cyanamide 2 „ sulphate of potash	10·56
5	2 „ bone meal 1 „ sulphate of ammonia 150 „ pen manure	14·22
6	2 „ superphosphate of lime 1 „ sulphate of potash 150 „ pen manure	13·75

The manures were spread broadcast, about 3 or 4 feet from the trunk of the trees and 2 feet from the edge of the drains, and the surface soil loosened to a depth of about 6 inches with the aid of a fork.

Records of pickings are being kept from July 1, 1911. Printed forms were supplied to the owners for forwarding the results of each picking.

The nature of the soil and approximate age of the trees under experiment are shown below.

Name of estate.	District.	Nature of soil.	Approximate elevation, feet.	Rainfall Jan. to Dec. 1910, inches.	Date when manure applied, 1911.	Age of trees, years.
Morvant	Laventille	Undulating clay loam	100	*	July	About 25
Beaulieu	Cedros	Flat sandy	25	80·56†	July	About 35
King's Bay	Tobago	Flat sandy loam	30	85·47	May	20 to 25

*No rainfall taken.
†Average rainfall for 11 years is 56 inches.

At Beaulieu the experiments are being made in these sections or series; each plot is represented by a single row of palm trees. The plots in one series have received similar treatment to the corresponding plots in the other two series.

The palm trees are planted at a distance of 24 feet, and the area under experiment on each estate is approximately 8 acres or 24 acres in all.

As these experiments have only lately been started, no records of yields are as yet obtainable.

THE BAY RUM AND BAY OIL INDUSTRIES OF ST. THOMAS AND ST. JAN.

BY W. C. FISHLOCK,

Agricultural Instructor, Virgin Islands.

During comparatively recent years the Danish Island of St. Thomas has become the centre of an important and growing trade in bay rum. This pleasant and refreshing adjunct to the toilet is produced in large quantities in St. Thomas and St. Jan, in the first named place chiefly by the admixture of bay oil with Demerara rum or highly rectified alcohol, and in the latter by distillation, which process will be described later.

The centralization of this industry in St. Thomas is probably due to several causes. In the first place, the neighbouring island of St. Jan affords a supply of bay leaves of good quality; secondly, and perhaps of first importance, there have always been low import duties on rum and alcohol in St. Thomas; these have varied from 3 to 6 per cent. *ad valorem*, the latter rate being now in force.

With the high duties and restrictive legislation on rum which obtain in many of the English islands, it is difficult to see how a bay rum industry could be established; but, as the writer hopes to show, there appears to be no reason why the English islands should not join in the oil trade, as the demand for the article appears likely to exceed the supply.

Doubtless, another factor in favour of St. Thomas in this trade is the fine shipping facilities afforded by the port.

It should here be mentioned that no bay leaves are grown in St. Thomas, all the oil and leaves used in the manufacture of bay rum in that place being imported.

In this paper the term 'bottle' means one-sixth of an Imperial gallon.

Historical Notes.

The industry seems to have been developed chiefly during the last fifty years, and would appear to have had its inception in St. Thomas.

The writer is indebted to Mr. Valdemar Riise, of the Apothecary Hall, St. Thomas, for the following notes on the history of the industry in St. Thomas:—

'In answer to your inquiry, I regret that I am not able to give you much information about the early history of bay rum in this place, as the sale of it was in full swing when I came to St. Thomas in 1878. Bay rum was then well known in the United States, which has always been its principal market. I remember, many years ago, that French's bay rum was sold in New York, and this French, who made bay rum of an ordinary quality, was a merchant here. Bay rum was officinal in the United States *Pharmacopoeia*, but is left out in the last edition. My father, A. H. Riise, manufactured bay rum and exhibited it for the first time at the Centennial Exhibition in Philadelphia in 1876, where it obtained the Centennial Medal. He actually distilled the bay rum from the leaves and seed of bay trees with rum and coined the words 'double distilled' which are to-day used by all manufacturers here, who have no still whatever.

'In Porto Rico it is largely manufactured, as is the bay oil, and this quality bay oil is very fine. In many of the West Indian islands the oil is produced, but in my opinion of an inferior quality.

'There exist different varieties of the bay plant with quite different odours, some smelling strongly of anis, others of lemon grass, and both spoil the fresh aroma of the genuine bay oil.

'I regret I am not able to give you further information, and do not believe anything more is known about the early history of this industry.'

THE BAY TREE.

DESCRIPTION. The tree from which the bay oil of commerce is obtained has been variously described as *Pimenta acris*, *Myrica acris*, *Caryophyllata acris*, *Caryophyllus racemosus*, and *Eugenia Pimenta*.

Probably bay oil has been obtained from two or more distinct species of plants, and it is very likely that, as the writer's observations go to show, there exist many varieties of the tree yielding ordinary bay oil. There is evidence to show that some of these varieties yield a much better class of oil than others, but much further investigation is required before the different varieties can be referred to their true place as regards yield and quality of oil.

The trees growing in the island of St. Jan show distinct varietal forms. In general, they are of handsome appearance, with dark-green, glossy leaves. The leaves are thick, almost coriaceous, in texture. The habit of the tree is upright, with ascending branches. The average height seems to be about 20 to 40 feet.

The size and shape of the leaves vary a good deal, as the specimens and photographs exhibited show. The leaves of the varieties having the best aroma are usually of a lighter green, and more pointed in shape, than the leaves of the inferior varieties There is also a tendency for the leaves of the better varieties to curl. The tree sheds its bark annually, the latter peeling off in long strips which roll up in pipe form.

HABITAT. The tree seems to occur in many of the West Indian islands. In Tortola the false bay, or lemoncilla, occurs, but the writer has not found any examples of the true bay growing wild. In the island of St. Jan it grows rather sparsely in thinly wooded places, and at elevations of 500 to 1,500 feet. Many of the older trees were recklessly cut down for the sake of their leaves, in the early days of the industry. The tree thrives well in fairly open situations and will grow at sea-level. The soil where the trees are found growing wild is usually of a rather close, loamy texture, and overlies ancient rocks. The young trees are found growing as an undergrowth among other forest trees.

VARIETIES. As has been mentioned already, many varieties of the true bay, as it may be termed, exist. Before these are noticed, however, it will be well to describe what may be called the false bay, or lemoncilla. This tree is very similar in to the true bay in general appearance, and a careless person may easily confuse them. The distinction of the two trees is, however, vital. The oil produced from the false bay is valueless, or worse than valueless, for the purpose of making bay rum; for even a small admixture of the false oil will spoil a large quantity of bay rum. There is no reliable guide by which to distinguish the two trees but the sense of smell. The leaves of the false bay, when crushed in the hand, yielded a rank, unmistakable odour.

It cannot be too strongly urged that the mixing of the two kinds of leaves is fatal; for the maker of bay rum, once a grower has supplied him with mixed oil, will very carefully avoid that source of supply.

To return to the true bay, it seems that varieties exist which not only differ in the quality, but also in the quantity of the oil they yield, and investigation and experiment along these lines should be of great value to the industry, as enabling the producer to control the yield and quality of the oil that is made. There can be no regularity or standard, in this matter, while the oil is the produce of wild and semi-wild trees.

CULTIVATION. Hitherto, there has been little in the way of genuine cultivation attempted. In the island of St. Jan, the practice has been simply to clear the bush and trees from areas where bay seedlings are found growing wild, thus enabling the trees to develop. In this way, some thousands of trees have been established; but as has been noted already, numerous varieties exist side by side.

The older trees produce seeds freely, but these are greedily devoured by birds, hence it would be necessary to protect the trees in some way, if seed were to be collected for planting. It is asserted that the seeds germinate more freely after passing through the stomach of a bird.

There would appear to be good reason for believing that systematic cultivation of these trees would be remunerative. They could be grown in situations where it would be inconvenient to raise many other crops, and they will thrive in any ordinary soil, provided that it is not too light and dry. They are hardy, will stand a good deal of drought, and do not appear to suffer from insect attack in any marked degree.

If the trees are grown in bush form, a distance of 10 feet apart each way would be sufficient. At this distance, there would be about 400 trees to the acre.

In regard to picking and yield of leaves, growers in St. Jan recommend that a first picking be made when the trees are about four to five years old; for it is asserted that by so doing the trees are kept in a better shape and induced to branch more freely. The yield of a well-grown tree at five years old is said to be about 15 ℔. per picking. Picking is usually done in the dry season, but the trees are sometimes picked twice a year. A tree ten years old will yield 60 to 100 ℔. of leaves per annum.

Green leaves are sold in St. Jan at the rate of 2c. per ℔. At this price, a tree yielding 50 ℔. of leaves would be worth 4s. per annum.

The general opinion seems to be that the dry months, that is February, March and April, comprise the best picking season. Leaves are picked, however, all the year round, as they are required.

In picking the leaves, the ends of the branches are broken off, but only the green portion of the wood should be included. The usual practice is to break off the twigs, but the writer would recommend cutting with a small pair of shears; such a method would be less liable to damage the trees.

Clean cultivation would be unnecessary; periodical cutlassing, or better still, the growing of leguminous cover crops, is all that would be required.

The Sources of the Supply of Bay Oil and Leaves.

It has already been stated that no leaves are grown in St. Thomas, all the oil and leaves used there being imported. The chief source of supply at present seems to be Porto Rico, whence large supplies of bay oil are drawn. There is a possibility, however, that this supply will diminish, as it is stated that there is a tendency to send more of the Porto Rico article to America. The St. Thomas bay rum makers view the oil produced in the English islands with great suspicion. They say that it is often adulterated with inferior oil, and for this reason they do not care to handle it. This is distinctly unfortunate, as there can be no doubt that oil of as good a quality could be produced in Dominica, for example, as in St. Jan. The oil from the latter place has a good reputation and always commands the best price in the St. Thomas market.

Bay trees of the good variety are known to exist in the following islands: Antigua, Barbuda, Montserrat, Dominica, and Saba, among others. The writer has been informed by bay rum makers, however, that the leaves from these places cannot be depended upon, owing to the admixture of inferior kinds. Possibly this mixture is by accident and not design, owing to carelessness or ignorance of the distinction. In either case, it is most important that the good kind should be well known and easily distinguished by growers or their agents. There can be no satisfactory trade relations established till this is accomplished.

The Distillation of Bay Oil.

For the purpose of distilling oil, the leaves and young portions of the branches are used, and they may be used either fresh or dried. Mature leaves only should be used if a high grade oil is desired.

The leaves, whether fresh or dried, are placed in the retort of a copper still, the size usually employed being of 200 gallons capacity. A still of this size will hold about 400 ℔. of green leaves. After the leaves have been put into it, the still is filled with water, and about 35 ℔. of salt is added, or in place of the salt, sea-water may be mixed with the fresh water used, in the proportion of one-third of sea-water to two-thirds of fresh water. This matter is most important, as addition of salt, or sea-water, adds greatly to the amount of oil obtained.

The distillate is collected in a specially constructed receiver, which is so arranged that water coming over can be run off without waste of oil.

In regard to yield, this varies with the season, and character of soil and climate where the leaves are grown, but an average yield is a bottle of oil from 130 to 140 ℔. of green leaves.

There are two kinds of oil known to distillers: the first oil that comes over is a light oil, of a greenish-brown colour; this is followed by a darker, heavier oil, which separates from the lighter soil, by sinking. Both kinds seem to be used indiscriminately by bay rum makers.

The samples exhibited will illustrate the characters of the two oils. The light-coloured oil darkens on exposure to light.

Preparation of Bay Rum.

Bay rum is prepared in two ways—by distillation, and by mixing bay oil with white rum or rectified alcohol. The bay rum made by distillation is the best article; it is prepared in the following manner. About 400 lb. of green leaves, or 200 lb. of dried leaves, is placed in the retort of a copper still of 200 gallons capacity, 65 gallons of Demerara rum is added and the still is then filled up with water. The whole of the distillate is collected, and this forms the genuine distilled bay rum of commerce.

Bay rum that is made by mixing bay oil and rum is not so good as the distilled article. It is prepared by mixing 2 bottles of bay oil with about 100 gallons of rum. A little magnesia is added, to aid blending.

Prices of bay Oil.

As has been stated already, the oil produced in the island of St. Jan always commands the best price in the St. Thomas market. The usual price for this oil is 18*s.* to 20*s.* per bottle. The oil produced in Porto Rico comes next in repute, and sells at about 16*s.* per bottle The oil from the English islands, as has been indicated, has a bad name in St. Thomas; some bay rum makers will not handle it at all. Buyers say that this oil is often mixed with oil from the false bay or lemoncilla. Recent enquiries resulted in offers of 12*s.* to 14*s.* per bottle.

There is an import duty of 6 per cent. *ad valorem* on bay oil imported into St. Thomas.

The Market for Bay Rum, Bay oil, and Dried Bay Leaves.

At the present time, there is a considerable demand for bay oil in St. Thomas, and this demand seems to be growing.

There is also, it appears, a considerable demand for bay oil in New York.

Large shipments of bay rum are made from St. Thomas to the growing countries of Central America, where there is a good market for this article.

In the year 1907, dried bay leaves to the value of £369 were shipped from Dominica to America, the exports of the same material to England during that year being £72 in value.

Factors Determining the Production of a High Class Oil.

The conditions necessary to obtain a high class oil include :—

(a) The use of leaves of good quality only.

(b) The use of mature leaves only.

(c) The rejection of doubtful kinds, most especially the lemoncilla.

(d) Absolute cleanliness in connexion with the distilling apparatus.

Conclusions.

There would appear to be an opening for the establishment of a moderate trade in bay oil and dried bay leaves.

Makers of bay rum in St. Thomas have expressed their belief that the industry is capable of expansion, and also their desire to purchase good grades of oil at fair prices. Makers of bay rum in St. Jan are also desirous of opening up new supplies of dried leaves.

It is most important, however, that only the best grades of oil and leaves be supplied If this be done, confidence will be established between the producer and consumer

Appendix.

(By Mr. H. A. Tempany, B.Sc.)

Mr. Fishlock's paper seems to show that there is a distinct opening for the disposal of bay oil and bay leaves from the English islands, in St. Thomas, provided that the quality of the leaves and oil is reliable.

Experience with bay oil distilled by the native distillers of the Leeward Islands would tend to prove that the inferior character of oil, which is sometimes produced, is due not to wilful adulteration by the distillers, but either to carelessness or ignorance, whereby the heavy oil is lost and the light oil only collected. In several instances samples have been referred to the Government Laboratory for the Leeward Islands, which have been condemned by New York dealers on the ground that they have been adulterated with kerosene, but on examination have been proved to consist solely of light oil to which no heavy oil has been added. In some few cases, this may perhaps have been aggravated by the demand existing at one time in the New York market for what was termed 'extra strong bay oil,' which consisted of heavy oil only and commanded special prices. The separate marketing of this part of the product of course, resulted in a surplus of light oil.

The yield of the oils is stated by Mr. Fishlock to be $\frac{1}{6}$-gallon, or $26\frac{2}{3}$ fluid oz. from 120 to 140 lb. of green leaves. It would be interesting to know what is the yield from the air-dry leaves, as the moisture content of leaves which are regarded as green is likely to vary in wide limits.

In experiments conducted at Antigua and described in the *West Indian Bulletin*, Vol. IX, p. 272, 70 lb. of air-dry, old leaves yielded $17\frac{1}{2}$ fluid oz. of oil.

The statement made by Mr. Fishlock that mature leaves give a better class of oil than young leaves is borne out by experience in Antigua, (see article in the *West Indian Bulletin* above referred to), the results obtained showing that a larger yield and a better class of oil results from the use of mature leaves.

The ultimate criterion of quality in bay oils is the amount of eugenol contained in them: the higher the eugenol content the better the oil.

This is indicated by the phenol content in the analytical results. In a normal sample of bay oil, the phenol content averages between 50 and 60 per cent. In distilling bay leaves, the composition of the oil obtained varies largely, the more volatile products coming over first and relatively little eugenol; as the distillation proceeds the amount of eugenol in the distillate increases, as at the same time does the specific gravity. It may be added that the amount of heavy oil obtained depends on the conditions obtaining at the time of collecting the sample. Both light and heavy oils are soluble in one another, and if a layer of light oil is present on the surface of the water in the receiver, the heavy oil falling through this layer may be dissolved and so remain on the surface; if, on the other hand, the receiver has been recently changed, there being no light oil present to absorb the heavy oil, it will fall to the bottom of the receiver.

Mr. Fishlock draws attention to the existence of a number of varieties of bay trees. The existence of the lemon-scented variety is now well recognized, and its use in distilling can be avoided. Another tree which may possibly be confused with the true bay (*Pimenta acris*) is *Canella alba*, locally known in Antigua as False or Bastard Cinnamon. The distinct differences in the character of this plant from *Pimenta acris*, together with the absence of the characteristic odour of bay oil, render it easy to distinguish it. Among the natives of Montserrat it is current report that two distinct varieties of the true bay (*Pimenta acris*) do exist; these are known locally as the Red Cinnamon and the Black Cinnamon, respectively. I have never yet been able to get the two varieties pointed out to me, nor yet to understand wherein the difference between them consists; but it is interesting in the light of Mr. Fishlock's observations.

Under the conditions governing the small production of bay oil in the Leeward Islands at present, wherein the cultivation of the leaves is left entirely in the hands of ignorant and unskilled peasants, it is hardly a matter for wonder, with the existence of several kinds of leaves which may readily be confused with the true bay, that the leaves of the true bay occasionally get mixed with those of other varieties. The entire source of supply at the present time is from trees growing in a state of nature.

Trials are at the present time being made both in Antigua and Montserrat with the cultivation of small areas of bay trees, with the idea of endeavouring to ascertain whether such an undertaking is likely to be profitable. In carrying this into effect the plan intended is to keep the trees trimmed to shrub form so as to facilitate the gathering of the leaves. The experiments have not yet been sufficiently long in progress to permit of the achievement of any results.

THE CLASSIFICATION OF SWEET POTATOES.

BY W. ROBSON,

Curator, Botanic Station, Montserrat.

An attempt has been made to classify the forty or so varieties of sweet potato at present in cultivation at the Montserrat Experiment Station. The system of classification is that originally adopted by R. A. Price, horticulturist of the Texas Experiment Station in 1893, which is described in *Farmers' Bulletin* No. 129 of the United States Department of Agriculture.

This system divides sweet potatoes into three groups having (a) split or lobed foliage, (b) shouldered or slightly lobed foliage, and (c) round or entire foliage. This foliage system, taken in conjunction with a description of the vines and roots, is considered to be sufficient to identify any variety of sweet potato. Whether the characters which enter into this system of classification will be found to be sufficiently constant when sweet potatoes are grown under a variety of conditions and on different soils, in the West Indies, so as to enable a correct identification of varieties to be made, is a matter for further investigation.

That there is an urgent need for some such system of classification, whereby the cultivator can establish the identity of his varieties, must be allowed, as there is very little doubt that at the present time varieties are being grown in some of the experiment stations, the names of which are incorrect.

A large proportion of the varieties now described are of local origin, or at least have been grown by the peasantry in Montserrat presumably for a very long period. It may be useful to indicate the names of the varieties obtained locally.

They are: Jackass, North No. 1, North No. 2, North No. 3, North No. 4, Bett Weeks, Massa No. 1, Massa No. 2, Bobo Daley, Humbug, Silly, Week's, Amyer, Venus, Black Amyer, Victoria, Dominica, Chibble, Nor'ard 18, Geranium, Jim Gage, Mingo, Francis.

The varieties imported to the Experiment Station within recent years are, Quildon, Trinidad No. 2, Bluebell, Hen and Chickens, Elijah, Gentleman's Table, Red Bourbon, White Gilkes, Black Vine, Caroline Lee, Barbados Barrel, Spooner, Annie, Montserrat Mamma, Shiprock, and Harper.

CLASSIFICATION OF VARIETIES OF THE SWEET POTATO.

A. SPLIT OR LOBED FOLIAGE.

(*a*) *Red Potatoes*

(1) Purple veins. Red Bourbon, Venus, Black Amyer, Chibble, Harper, Nor'ard 18, Annie, North No. 3, North No. 4..

(2) Green veins, purple midrib. Geranium.

(3) Green veins. — — —

(*b*) *Yellow or White Potatoes.*

(1) Purple veins. White Gilkes, Black Vine, Caroline Lee, Jim Gage, Barbados Barrel, Spooner, Montserrat Mamma, Mingo, Francis.
(2) Green veins, purple midrib. Dominica.
(3) Green veins. Victoria, North No. 2.

B. ROUND OR ENTIRE FOLIAGE.

(*a*) *Red Potatoes.*

(1) Purple veins. Shiprock, North No. 1, Massa No. 2.
(2) Green veins, purple midrib. Trinidad No. 2, Bett Weeks.
(3) Green veins. Massa No. 1

(*b*) *Yellow or White Potatoes.*

(1) Purple veins. Bobo Daley.
(2) Green veins, purple midrib. Jackass, Quildon.
(3) Green veins. — —

C. SHOULDERED OR SLIGHTLY LOBED FOLIAGE.

(*a*) *Red Potatoes.*

(1) Purple veins. Hen and Chickens, Elijah, Amyer.
(2) Green veins, purple midrib. Silly.
(3) Green veins. — —

(*b*) *Yellow or White Potatoes.*

(1) Purple veins. Bluebell
(2) Green veins, purple midrib. — —
(3) Green veins. Gentleman's Table, Humbug, Week's

Description of Sweet Potatoes, Montserrat.

VARIETIES WITH SPLIT OR LOBED FOLIAGE. *

Variety.	Colour of stem.	Colour of petioles.	Colour of venation.	Character of growth.	Colour of potato.	Colour of interior (raw).
Red Bourbon	purple, mottled green	purplish green	purplish	bunching	light-red	white
White Gilkes	green, slightly mottled purple	purplish green	blackish purple	vigorous	white	white
Black Vine	uniformly blackish purple	purplish green	purplish	very vigorous	white	yellowish white
Caroline Lee	uniformly reddish purple	green or purplish	purplish	vigorous	very white	yellowish white
Venus	purplish green	purplish to green	purplish	very vigorous	purplish red	white, mottled purple
Barbados Barrel	green	green, top purple	slightly purple	slender	yellowish white	yellowish white
Black Amyer	brownish purple	brownish purple	blackish purple	vigorous	dark-red	yellowish white
Victoria	uniformly pale green	pale green	pale green	vigorous	yellowish white	white
Dominica	uniformly green	green, trace purple at base	green, base midvein purple	rather slender	white	very white
Chibble	green, mottled purple	slightly purple	slightly purple	fairly vigorous	red	yellowish white
Harper	green, mottled purple	slightly purplish	slightly purplish	fairly vigorous	red	very white
Nor'ard 18	green, mottled purple	green or purplish	green to purplish	moderate vigour	red	yellowish white or pinkish
Geranium	green, mottled purple	slightly purplish	midvein purplish	moderate vigour	red	very white

VARIETIES WITH SPLIT OR LOBED FOLIAGE.—(*Concluded.*)

Variety.	Colour of stem.	Colour of petioles.	Colour of venation.	Character of growth.	Colour of potato.	Colour of interior (raw).
Jim Gage	green to purple	green or purplish	blackish purple	vigorous	yellowish white	yellowish white
Spooner	uniformly reddish purple	green to purplish	purplish	very vigorous	yellowish white	yellowish white
Annie	uniformly reddish purple	reddish purple	reddish purple	very vigorous	light-red	yellowish white
Montserrat Mamma	green	green, purple base	blackish purple	moderate vigour	very white	white
Mingo	green, or slightly purple	green, or slightly purple	purplish	vigorous	yellowish white	nearly white
North No. 4	green to blackish purple	green to blackish purple	purplish	slender	dark-red	white
Francis	green, or slightly purple	green, or slightly purple	purplish	moderate vigour	yellowish white	yellowish white
North No. 2	green, or slightly purple	green, top purple	green	vigorous	light-red	white
North No. 3	green, or purplish	green, or purplish	purplish	slender	brick-red or pinkish	yellowish white

VARIETIES WITH ROUND OR ENTIRE FOLIAGE.

Variety.	Colour of stem.	Colour of petioles.	Colour of venation.	Character of growth.	Colour of potato.	Colour of interior (raw).
Jackass	uniformly green	uniformly green	green, midvein purplish	vigorous	yellowish white	yellowish white
Shiprock	blackish purple	purplish	purplish	moderate vigour (straggling)	dark-red	yellowish white
North No. 1	green or purplish	green, or purplish	purplish	vigorous	brick-red or pinkish	yellowish white
Trinidad No. 2	green	green	green, base midvein purplish	gross	pinkish	yellowish white
Bett Weeks	green	green	green, base midvein purple	gross	dark-red	yellowish white
Quildon	green	green	green, base midvein purplish	gross	yellowish white	yellowish white
Massa No. 1	light-green	light-green	green	vigorous	purplish red	yellowish white
Massa No. 2	green or purplish	purplish	purplish	moderate vigour	purplish red	yellowish white
Bobo Daley	green	green, purplish top and bottom	slightly purple	slender	yellowish white	nearly white

VARIETIES WITH SHOULDERED FOLIAGE.

Variety.	Colour of stem.	Colour of petioles.	Colour of venation.	Character of growth.	Colour of potato.	Colour of interior (raw).
Bluebell	green, mottled purple	purplish, base darker	blackish purple	vigorous	white	yellowish white
Hen and Chickens	green	green, or slightly purple	purplish, base darker	slender	dark-red	yellowish white
Gentleman's Table	green	green	green	moderate vigour	very white	very white
Elijah	green	slightly purplish	purplish	vigorous	light-red	yellowish or pinkish white
Humbug	green	green	green	slender	yellowish white	decidedly yellowish
Silly	pale-green	green	green, trace purple base midvein	vigorous	pinkish	yellowish white
Week's	light-green	light-green	green	vigorous	yellowish white	yellowish white
Amyer	green, or slightly purple	green or slightly purple	purplish	moderate vigour	pinkish	yellowish white

CASSAVA STARCH AND ITS USES.

BY E. EVERINGTON,

Dominica.

Starch enters into our daily lives in so many forms that its production should be carefully considered by all planters. It forms one of the principal items of our food-supply. The cotton clothes so largely worn in the tropics are woven from yarn sized with starch. They are afterwards stiffened and finished with it. It is the principal item of expense in the laundry. The so-called gum on the envelopes and postage stamps is made from starch, converted into dextrin. So is glucose and much of the alcohol used in the arts and industries. With an article for which the want is so great there is is no fear of a lack of demand, and the question resolves itself into one of quality and cost of production.

We have in the tropics a number of starch-producing plants, but none of these can compare in quantity with the yield of cassava, and the starch produced from the cassava root is equal to, if not better than, the very finest potato starch; and cassava has the advantage of containing 33 per cent. of starch, as compared with 16 per cent. from the potato.

Most extravagant statements have been made in regard to the amount of cassava which can be produced per acre, but for the most part these calculations have been based on the multiplied results of small selected spots. Over a number of acres I have reaped as much as at the rate of 12 tons to the acre, but this land was exceptionally favourable and well placed, and talking it all round, 8 tons is the fairest average to work on.

I have found that areas planted a second and third year in succession will yield a larger quantity of roots, but that the starch content is less each year.

With regard to variety, local conditions can alone prove their worth. The bitter kinds certainly contain more starch than the sweet.

I have had numbers of varieties from Jamaica, Guadeloupe and Montserrat, but none have done so well as the variety known as Black Stick, though this closely resembles the Blue Top of Jamaica, and though this variety does not produce a large root there are a large number of tubers to each plant and this variety can be reaped in ten months and contains a large percentage of starch. I have got as much as 29 per cent. from this variety.

Cassava grows and yields far more prolifically near the sea coast. It prefers a light soil and dry rather than wet. Heavy soils produce small yields, and the roots are difficult to handle.

With regard to manufacture, the cassava starch has a great advantage, for the entire process for the complete extraction of the starch. From the time the roots are laid down at the factory, until the starch is finished ready for the market, is only three days, while Indian corn (or maize), under the most favourable conditions, requires twelve to fourteen days.

The first stage of the process is to free the roots from dirt, etc., by washing. They are then conveyed to the rasper or grater, which in my factory consists of a revolving drum run at 2,000 revolutions per minute. The drum is inset with knives specially made to meet the requirements of the cassava root fibre. The roots are fed in from above, and jets of water play on the roots as they reach the drum. The pulp falls through the lower end to a tank fitted with a centrifugal pump, which drives the milk up on to a washing table, where it again meets a further series of water jets, which separate the starch from the meal. From the washing table the meal runs on to a long gyrating sieve, which contains two sets of straining trays of different mesh, one below the other. The starch milk runs through into the washing tank and the pulp is automatically ejected into a truck, where it is carried off to be converted into a stock food.

The starch having settled and the water having been drawn off, fresh filtered water is added, and after thorough stirring and washing the starch and water are pumped over to the final settling tanks, passing through fine phosphor-bronze strainers on the way. where, when the starch has again settled, it is taken out and dried mechanically with centrifugals and a hot air process.

There are numerous pitfalls for the starch manufacturer, and the most important item is to prevent souring and fermentation.

The atmosphere of an ordinary starch factory is said to contain as many as 200 to 50,000 living germs and ferments per cubic centimetre, varying according to the season of the year. Looking at these figures, it is not to be wondered that the starch in the various stages of its manufacture, exposed to such an atmosphere, is invaded by millions of these organisms and becomes sour. To prevent this, the greatest care has to be taken to ensure absolute cleanliness, pure filtered water used, and the manufacture completed with as much rapidity as possible and with no delay between the various processes. The refuse pulp is pressed and baked and then sweetened, and the results of the food manufactured have been altogether most satisfactory.

The analysis of a sample sent to England proved it to contain rather more oil and albuminoids than molascuit; otherwise the constituents were much the same. Since, I have vastly improved the food, and horses and stock of all kinds thrive on it, and for poultry it is found to be a good egg producer.

The name cassava should properly apply only to the purified starch derived from the roots of the plants, but it has passed into general use to designate the plant itself.

The botanical name is *Manihot utilissima*, and the plant is a native of South America where it is converted into tapioca and exported as such. The tapioca is divided into three classes: flour, flake and pearl. The tapioca flour is the same as our cassava starch. For making flake, the damp starch is rasped and sifted and the flour is placed near the cooking pans. It is then cooked in small portions at a time until the starch has swollen and altered. It is now tough and gelatinous, and in irregular, flatty lumps which are translucent. It is now sifted and the larger lumps broken up, and the whole placed on iron or copper plates and dried by a gentle heat till quite dry and crisp. The siftings bring about the

same price as the flake; both vary in price according to the colour, which is most important. The operations for 'pearl' are much the same as for flake, but before being cooked it is shaken on a cloth, stretched on a frame, which rolls the damp starch into balls. This is quite an art and requires a good deal of practice. It is then cooked and dried.

In the manufacture of dextrin from cassava, the starch is submitted to a high temperature, preferably in contact with the diluted vapours of nitric acid. The action of the heat, in connexion with the slight quantity of nitric acid present, is sufficient to convert the starch into dextrin, in which form it is used for postage stamps and the sealing edge of envelopes. For the preparation of glucose, the pulp is pumped direct into an open converter—a vat of proper dimensions to receive it—and heated with a copper steam coil. In this the pulp is reduced with water and the proper amount of hydrochloric acid added. Then it is raised to the boiling point, and the starch and much of the fibre are rendered soluble. From thence it is run into the closed copper converter, and subjected to a steam pressure of 30 lb. to the square inch for ten minutes, or until the proper degree of conversion is obtained; this is controlled by means of iodine colour tests. These are made by adding a definite number of drops of standard iodine solution to a test tube of the cooled glucose liquor. The tint at which the conversion is considered complete is that corresponding to the polariscope reading of 135.

The proper degree of conversion having been reached, the liquor is now run into the neutralizer where it is nearly neutralized with carbonate of soda; after this it is run through filter presses and the nearly neutral solution of glucose at 15° B. passed over charcoal into the charcoal filter, from thence to the triple effect evaporator, where it is boiled down to a gravity of 28° B. in the vacuum, pan and thence passes to the coolers, ready to be barrelled.

THE WATER-SUPPLY OF ANTIGUA.

BY H. A. TEMPANY, B. Sc., F.I.C., F.C.S.

Superintendent of Agriculture for the Leeward Islands.

The question of water-supply has always been of vital importance in the island of Antigua, by reason of the low rainfall, liability to drought, and absence of large bodies of fresh water.

In the following pages the attempt has been made to review the existing sources of water-supply in respect of their various origins and chemical characteristics.

The analytical data supplied comprise in the majority of cases :—

The total solids
The temporary hardness as calcium carbonate
The chlorine
The sodium chloride eqivalent to chlorine
The oxygen absorbed in three hours by the Forschammer process.

These factors, though by no means constituting a complete examination, are sufficient to enable a fairly correct estimate to be formed of the characters of the various waters.

In all, some seventy-eight different samples of water are reported on below ; of these thirty-five samples were taken and examined for the purposes of this investigation, while the remainder are taken from data accumulated in the records of the Government Laboratory during the past twenty-one years.

In all cases the samples were drawn under the direction of the Laboratory, and care was taken to ensure that they accurately represented the condition obtaining. In the various analyses, the results are given both in parts per 100,000 and grains per gallon.

In regard to the various analytical data, the following information is given to facilitate judgment in the samples.

TOTAL SOLIDS. The amount of dissolved solids depends largely upon the nature of the soil through which the water has penetrated. River water usually contains 7 to 21 grains per gallon. Shallow well and spring water may contain 21 to 150 grains per gallon or even more. Deep well waters may contain 14 to 50 grains per gallon, but the proportion may vary considerably beyond these limits. Water which leaves a large residue in evaporation is not suitable for manufacturing purposes, since it tends to produce scale or boilers, etc., but such water is not necessarily unsuited for drinking purposes.

TEMPORARY HARDNESS. This is due to the presence in solution of calcium and magnesium carbonates. It may range from 1·4 to 40 grains per gallon. A considerable degree of hardness does not appear to have any effect on the health of the consumer.

CHLORINE. The amount of chlorine is an important factor in many of the spring and well waters of Antigua. Its presence is almost invariably traceable to saline deposits resulting from the gradual elevation of the shallow sea bottom in recent geological times, or to seepage from the sea. In the results given, the chlorine present is also estimated in terms of sodium chloride (or common salt). As a limit for drinking purposes, 100 grains per gallon may be stated.

The oxygen consumed by the organic matter affords a means of estimating the amount of organic impurity present in the water.

The following table, taken from Clowes and Coleman's Quantitative Analysis, shows the amount of oxygen required per 100,000 parts of waters of different degrees of purity:—

	Upland surface water.	Water from other sources.
Water of great purity	Not exceeding 0·1	Not exceeding 0·05
Medium purity	From 0·1 to 0·3	From 0·5 to 0·15
Doubtful purity	From 0·3 to 0·4	From 0·15 to 0·2
Impure	Exceeding 0·4	Exceeding 0·2

The water-supply of Antigua is originally derived from the following primary sources:—

(a) Surface drainage.
(b) Rainwater from house roofs and catchwaters.
(c) Ponds and stagnant streams.
(d) Springs and wells.

At the present time, water is distributed in pipes to the town of St. John's, and to about half of the country villages of the island, from two reservoirs, one situated at Grays Hill, about 1 mile from St. John's, the other at Wallings in the southern and more mountainous part of the island.

To the Grays Hill reservoir, which affords a fairly adequate supply to St. John's, water is pumped from Body Ponds, about 5 miles south of St. John's. The water is derived partly from surface drainage from the surrounding hills, and partly from a series of shallow springs at the junction of the sedimentary beds which constitute the central plain of the island, and the eruptive rocks by which the more southern portions of the island are underlain.

The Wallings reservoir, from which about half the village population of the island is supplied, derives its water by surface drainage from the surrounding hills. It was constructed by damming the head of one of the numerous valleys in the district; the bottom of this forms the reservoir, while the sides constitute the collecting area.

The Grays Hill reservoir consists of two covered containers with a total capacity of 3,120,000 gallons. It possesses a set of sound filter beds as an adjunct to the containers.

Wallings reservoir has a capacity of 18,000,000 gallons.

The following analyses illustrate the composition of these two sources of supply :—

WALLINGS.

	1902.		1906.	
	Parts per 100,000.	Grs. per gallon.	Parts per 100,000.	Grs. per gallon.
Total solids	25·9	18·13	23·2	16·24
Temporary hardness as calcium carbonate	9·4	6·58	8·0	5·6
Chlorine	3·1	2·1	3·7	2·59
Equivalent to sodium chloride	5·1	3·6	6·1	4·3
Oxygen consumed in 3 hours	·127	·099	·291	·203

WALLINGS.

	1906.		1906.		December 1911.		December 1911.	
	Pts. per 100,000	Grs. per gallon.	Pts. per 100,000	Grs. per gallon.	Pts. per 100,000	Grs. per gallon.	Pts. per 100,000	Grs. per gallon.
Total solids	23·6	16·5	24·0	16·8	27·0	18·9	34·0	23·8
Temporary hardness	...	...	3·4	2·4	8·3	5·8	10·1	7·07
Chlorine	4·0	2·8	4·4	3·1	2·0	1·4	2·1	1·47
Equivalent to sodium chloride	6·6	4·6	7·2	5·0	3·3	2·3	3·5	2·45
Oxygen absorbed in 3 hours	·288	·132	·136	·095	·496	·347	·387	·271

Grays Hill Reservoir.

	1891.		November 1906.		July 1911.	
	Pts. per 100,000.	Grs. per gallon.	Pts. per 100,000.	Grs. per gallon.	Pts. per 100,000.	Grs. per gallon.
Total solids ...	53·7	37·6	40·0	28·0	62·6	4·31
Temporary hardness as calcium carbonate ...	...	...	9·4	6·6	30·4	21·3
Chlorine ...	10·4	7·3	2·5	1·8	15·0	10·5
Equivalent to sodium chloride	17·2	12·0	4·1	2·9	23·4	16·4
Oxygen absorbed in 3 hours	...	...	·174	·122	..	...

Grays Hill Reservoir.

November 1911.

	Pts. per 100,000	Grs. per gallon.
Total solids	54·0	27·8
Temporary hardness	22·2	15·5
Chlorine	10·0	7·0
Equivalent to sodium chloride	16·5	11·6
Oxygen absorbed in 3 hours.	·243	·170

The water from Wallings shows relatively constant characteristics, and considering its origin may be regarded a fairly satisfactory type of tropical upland surface water. The sample analyzed in November 1911 is somewhat an exception, as the organic matter is distinctly excessive. At the time the sample was taken the reservoir had become very low owing to prolonged drought, and the condition of affairs obtaining must

be looked on as exceptional. It is a noticeable characteristic of the water that it is usually turbid with suspended finely divided clay. This turbidity is a constant feature of the water, but can be removed by the addition of small quantities of suitable flocculating agents, whereby the clay becomes coagulated and subsides.

The Grays Hill reservoir water, on the other hand, shows much more variable characteristics. This is largely because of the double source from which the water is derived, this being partly from springs and partly surface drainage. Moreover, the fact that the water is pumped to the reservoir as needed, tends to make its quality more variable with season. In times of drought the total solids, hardness and chlorine rise, as the water is then almost entirely derived from underground sources; in times of rain these values fall, and the organic matter rises as the surface water then largely supplements that derived from the springs.

This is well illustrated by the samples taken in 1906, and in July and November 1911. The samples taken in November 1906 and November 1911 were after periods of rain, while that of July 1911 was taken during a protracted period of drought. As with Wallings, the water-supply is of a fairly satisfactory character, having regard to its origin. It is, however, as much harder water—a result of its origin being partly in underground sources. If the precaution is taken of boiling or filtering these waters, they may be regarded, on the whole, as quite suitable for domestic purposes, with the possible exception of the sample drawn from Wallings in November 1911.

Rainwater collected from the roofs of buildings and from catchwaters built for the purpose, and stored in tanks, constitutes an appreciable fraction of the water-supply of these districts of the island not at present connected with either of the two reservoirs.

Such a supply, though generally of a limited character, is usually satisfactory, provided the catchwater surfaces and the cisterns are reasonably free from sources of contamination. Neglect in this respect is apt to result in the production of waters of dangerous quality. This is especially likely to happen if the cistern is sunk below the surface of the ground, when cracks in the sides and bottom of the cistern allow of contamination taking place by seepage from the surrounding soil.

The following analyses illustrate the class of waters met with in this group :—

	A.		B.		C.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	4·80	3·36	12·0	8·4	4·8	3·36
Temporary hardness as calcium carbonate ...	...	...	...	...	...	...
Chlorine	1·75	1·22	..	...	1·25	8·75
Equivalent as sodium chloride	2·88	2·01	...	...	2·06	1·44
Oxygen absorbed in 3 hours ...	·152	·106	1·006	1·006	·115	·081

	D. 1909.		E. 1910.		F. 1910.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	8·2	5·74	11·0	7·70	14·0	9·80
Temporary hardness	4·0	2·80	5·6	3·90	4·5	3·15
Chlorine	1·9	1·33	2·8	1·96	2·9	2·03
Equivalent as sodium chloride	3·1	2·17	4·7	3·30	4·8	3·36
Oxygen consumed	·237	·166	·286	·199	·510	·357

	G. 1911.		H. 1911.	
	Parts per 100,000.	Grs. per gallon.	Parts per 100,000.	Grs. per gallon.
Total solids	14·0	9·8	30·0	21·0
Temporary hardness	2·12	1·48	2·52	1·76
Chlorine	4·70	·49	1·0	·7
Equivalent as sodium chloride	1·15	·81	1·65	1·16
Oxygen consumed	·062	·043	·021	·015

	I. 1911.		J. 1911.	
	Parts per 100,000.	Grs. per gallon.	Parts per 100,000.	Grs. per gallon.
Total solids	8·0	5·6	4·0	2·8
Temporary hardness.	3·53	2·47	1·81	1·06
Chlorine	1·1	·77	1·0	0·7
Equivalent as sodium chloride	1·81	1·27	1·65	1·16
Oxygen consumed	·120	·084	·123	·086

It will be seen that the amount of organic matter, as indicated by the oxygen consumed, varies very largely. Samples D, E, F were taken from the same cistern at successive intervals; after the first analysis the cistern was cleaned, but the increasing amount of organic matter tends to indicate that the source of contamination was growing in magnitude.

Ponds and stagnant streams at the present time also constitute a not important source of water-supply in many of the districts of Antigua, and as such must on the whole be characterized as very unsatisfactory.

As a rule, no precautions are taken to protect either the ponds themselves or the collecting area from which the water drains into them, from wholesale contamination by human beings and stock. Usually speaking, they consist of depression

in the ground which have been coated with a water-retaining puddle of clay.

The best of these public ponds are those situated at the southern eastern corner of St. John's, and known as the country ponds. These are fairly well constructed reservoirs deriving their water from drainage of the gently sloping lands to the east of the town and protected by means of iron railings.

The composition of waters of this class is illustrated in the following series of analyses.

	Country Pond, St. John's. 1911.		Scott's Hill Pond. 1911.		Monk's Hill, Pond I. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	4 0	2·20	52·0	36·4	28·6	2·00
Temporary hardness ...	1·51	1·06	10·6	7·42	...	...
Chlorine ...	1·00	·70	6·85	4·30	...	...
Equivalent as sodium chloride ...	1·65	1·16	10·60	7·90	...	...
Oxygen consumed. ...	·123	·66	1·700	·490	·990	·69

	Monk's Hill, Pond II. 1910.		Judges Pond. 1910.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	26·6	18·5	41·6	29·1
Temporary hardness ...	...	...	...	...
Chlorine	...	...	...	...
Equivalent as sodium chloride	...	.	...	...
Oxygen consumed	1·75	1·19	1·77	1·24

	Vernons Pond. 1911.		Creekside Stream. 1910.		Collins Stream. 1894.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	40·0	28·0	267·4	193·5	152·0	196·4
Temporary hardness	11·0	7·7	...	...	...	...
Chlorine	4·7	3·3	109·0	76·3	47·0	32·9
Equivalent as sodium chloride	7·7	5·4	179·6	125·7	77·2	54·1
Oxygen consumed	·68	·480	·190	·133	...	...

	Collins Stream. 1910.		Collins Stream. 1910.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	201·6	141·3	74·0	51·5
Temporary hardness	61·6	43·1	15·2	10·6
Chlorine	29·8	20·9	29·0	20·3
Equivalent sodium as chloride	49·0	34·3	47·8	33·5
Oxygen consumed	...	...	...	...

The water from the Country Pond is of a fairly satisfactory character, and testifies to the adequacy of the precaution taken to prevent pollution.

In the case of the other pond waters, however, the high content of organic matter, as shown by the oxygen consumed, is evidence of their unsatisfactory character as a source of water-supply. It may be added that the peasantry of the island are cautioned against the use for domestic purposes of waters from ponds which are not protected from pollution by stock, but at the present time this caution is largely disregarded.

The majority of the so-called streams in Antigua fall into the same category as the ponds, as sources of water. They consist in the main of channels which serve to carry off the surplus surface water in times of heavy rain, and dry up to form series of

stagnant pools in times of dry weather. An important exception is constituted in the case of the body of water known as Collins Stream which takes its rise in the south-eastern district of the island near the village of Liberta, and subsequently traverses the eastern part of the limestone district. In this latter area it is largely fed by springs derived from the older limestone formation, and in the driest season provides a moderate, but constant, flow of water. In wet weather this is of course considerably supplemented by surface drainage. The variation in composition at different seasons shown by the analyses demonstrates this.

A further important exception lies in the case of Body Ponds, already alluded to as one of the sources of the town water-supply of St. John's.

The fourth source of supply of water lies in the underground water made available by wells and springs. At the present time this constitutes a not unimportant local source of supply, but the opinion is expressed that it is capable of far greater exploitation than is at present the case.

The question of the possibilities of exploitation in this direction has already been dealt with by Dr. Watts in a memorandum, an abstract of which is appended to this paper. For purposes of classification the underground waters of Antigua may be divided into three groups :-

(a) Those derived from the limestone rocks of the northern and eastern portions of the island,

(b) those derived from the older sedimentary rocks underlying the central plain,

(c) those derived from the volcanic area of the southern district of the island.

Of these, the first group is the most important. The water-bearing strata consist of a series of compact limestones probably of Miocene age, and the view is advanced that these constitute a natural reservoir of water of large dimensions capable of being drawn on to supply fully the needs of the districts located on them and possibly also of yielding a sufficiency to supply other parts of the island.

Existing wells are all relatively shallow, the deepest not exceeding 50 feet, and it is probabie that in no case has more than the upper limit of the water table been tapped.

The composition of the waters of this area is illustrated by the following series of analyses. To facilitate comparison they are divided into three groups: (i)those of the northern and western or Popeshead district, (ii) those of the central and north eastern district, (iii) those of the eastern or windward district.

It may be added that, in the case of many of the well waters, in the following section of the paper, a high oxygen consumption may be regarded as evidence of pollution of the water at the point from which the water is drawn and not of the source of supply.

The Northern and Western or Popeshead District.

	Royals Well. 1911.		Public Spring, Cedar Grove. 1911.		Piggots Spring. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	82·0	57·4	146·0	102·2	80·0	56·0
Temporary hardness	41·5	29·1	51·0	35·7	24·5	17·2
Chlorine	7·8	5·5	37·7	26·4	19·6	13·9
Equivalent as sodium chloride	12·9	9·0	62·1	43·5	32·6	22·8
Oxygen absorbed	nil	nil	·10	9·07	·24	·071

	Thibous Well. 1900.		Gravenors Well. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	141·0	98·7	149·0	104·3
Temporary hardness ...	52·5	36·7	56·0	39·2
Chlorine	35·0	24·5	26·0	18·2
Equivalent as sodium chloride	57·8	40·3	42·8	30·0
Oxygen absorbed	...	...	·065	·046

	Winthorpes Well. 1911.		Fitches Creek Well. 1911.		Millars Well. 1906.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	126·0	88·2	168·3	118·0	183·0	128·0
Temporary hardness ...	54·5	38·1	44·9	31·4	47·1	33·0
Chlorine... ...	19·9	13·9	63·0	44·0	77·1	54·2
Equivalent as sodium chloride ...	32·8	23·0	103·8	72·5	127·0	89·0
Oxygen absorbed	·096	·067	·005	·004	...	...

	High Point Well. No. 1. 1911.		High Point Well. No. 2. 1911.	
	Parts per 100,000	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	766·0	536·2	894·0	625·8
Temporary hardness ...	41·3	28·9	55·5	38·9
Chlorine	386·0	70·0	454·0	317·8
Equivalent as sodium chloride	636·2	445·4	748·2	523·8
Oxygen absorbed	0·259	·181	·496	·347

	High Point Well. No. 3. 1911.		High Point Well. No. 4. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	163·0	114·1	120·0	84·0
Temporary hardness ...	33·5	37·6	43·9	30·7
Chlorine	29·4	20·6	13·7	9·6
Equivalent as sodium chloride	18·5	34·0	22·6	15·6
Oxygen absorbed	·195	·137	very	large.

NORTH-EASTERN AND CENTRAL LIMESTONE DISTRICT.

	Parham New Work. 1911.		Gilberts. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	110·0	77·0	130·0	91·0
Temporary hardness ...	56·7	41·1	52·4	36·7
Chlorine	8·9	6·2	23·4	16·4
Equivalent as sodium chloride	14·7	10·3	38·6	27·0
Oxygen absorbed	·099	·069	·609	·426

	Parham Lodge 1910.		Crabbs. 1910.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	203·0	143·5	192·0	154·4
Temporary hardness ...	36·0	39·2	56·0	39·2
Chlorine	88·0	61·1	90·0	63·4
Equivalent as sodium chloride	144·8	101·2	148·0	105·5
Oxygen absorbed	...	..	...	...

EASTERN OR WINDWARD LIMESTONE DISTRICT.

	Sion Hill Well. 1911.		Seatons Well. 1911.		Seatons Well. 1910.		Mayers Well. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	82·0	57·4	276·0	193·2	515·0	360·0	690·0	483·0
Temporary hardness ...	37·8	26·5	52·4	36·7	20·0	14·0	63·5	44·4
Chlorine ...	13·0	9·1	104·0	73·1	233·0	163·1	307·5	215·3
Equivalent as sodium chloride ...	21·4	15·0	172·0	120·4	371·5	261·8	506·3	354·4
Oxygen absorbed...	·356	·249	·085	·060	...	...	·489	·343

	Mayers Well. 1892.		Comfort Hall Well. 1911.		Waldronds I. 1901.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	491·0	344·0	690·0	483·0	646·0	452·2
Temporary hardness	76·0	53·25	64·5	45·2	31·0	21·7
Chlorine ...	242·9	170·0	338·5	237·0	288·0	202·0
Equivalent as sodium chloride	400·3	280·2	557·8	390 5	474·6	322·2
Oxygen absorbed	...	...	·395	·277	...	...

	Waldrons II. 1901.		Elliotts Spring. 1901.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	181·3	126·9	180·2	126·1
Temporary hardness ...	60·0	42·0	56·6	39·6
Chlorine ...	41·6	29·1	24·0	16·8
Equivalent as sodium chloride ...	68·53	47·98	39·6	27·7
Oxgyen absorbed ...	...	...	...	...

The above series of twenty-five analyses represent a moderately complete survey of the waters found in the upper layers of the limestone district so far as they have been explored.

As has been mentioned, the wells are all relatively of very shallow depth,—the result of the absence of proper appliances for boring.

The deepest well is that at Royals. This has a depth of between 40 and 50 feet, and the water from it may probably be regarded as typical of the water resources of the main limestone rocks. It will be seen that this water, though somewhat hard, as is to be expected when its source of origin is taken into consideration, is nevertheless of very high purity. Of the other wells, while many approximate moderately closely

to Royals, nevertheless an appreciable number of the samples differ very markedly from it, presenting a type of water which, owing to the large amount of chloride contained in them, are unfit for drinking and doubtfully useful for other domestic purposes. This is well shown in the case of the four wells at High Point, of which 1 and 2 are very salt, while 3 and 4 contain relatively small amounts of chloride. The wells at Mayers, Seatons, Comfort Hall and Waldrons I also show this character to a marked extent; but as a contrast, the waters from Waldrons II, Elliotts and Sion Hill are all satisfactory.

It is a characteristic feature of brackish wells of this type that wells with satisfactory waters are frequently found not far removed. The probable explanation appears to be that within recent geological times, the Northern district, or at any rate the lower lands, were immersed in a shallow sea; the gradual uplift succeeding this resulted in the formation of a series of pockets or salt ponds, which gradually drying up left deposits of a marly character and no great thickness rich in sodium chloride, and lying on the original limestones. When shallow wells are sunk into such local deposits the water resulting is brackish and it appears probable that the existence of such deposits explains the character of the well waters referred to above. Deeper boring would penetrate the older limestones and give access to a purer water-supply.

A somewhat high temporary hardness is characteristic of all of the waters from the limestone district, and is a result of the calcium carbonate dissolved in them and derived from the rocks in which they are contained. In all the analyses this presents a remarkably constant feature, in the majority of cases ranging from 40 to 60 parts per 100,000.

The organic matter as evidenced by the oxygen consumed varies very largely, and in many cases shows evidence of considerable pollution. Too much weight need not be attached, as in the case of shallow wells this can almost invariably be traced to accidental contamination from surface surroundings.

The opinion may again be expressed that moderately deep boring at any point in the limestone area would give access to a practically inexhaustible water-supply of high purity, the pervious nature of the underlying rocks rendering it of high water-retaining power.

The existence of large supplies of underground water is evidenced by the ready yields of water obtained from shallow wells, as also by the existence of such a body of water as Collins Stream, which traversing the eastern limestone district is fed throughout the greater part of its length by springs, and in the driest seasons always contains an abundant supply, notwithstanding the fact that the locality traversed by it is one of the driest in the island.

In view of the present inadequate character of the water-supply of Antigua, this source of supply may be regarded as worthy of most careful consideration and attention with a view to development.

The underground waters of the Central Plain are to a large extent characterized by a considerable degree of salinity

In Dr. Watts's memorandum already alluded to, attention has been drawn to this fact, and to the reason for it, namely that during recent geological time the island was submerged some 50 feet or so below its present level; the lower-lying lands became covered with water, and the subsequent elevation has left the low-lying narrow belt of the central plain impregnated with salt in similar fashion to the salt patches in the limestone district, the existence of which has already been pointed out. This belt stretches from St. John's to Willoughby Bay.

The following data give an idea of the composition of water in this area:—

	Gambles Spring I. 1906.		Gambles II. 1906.		Gunthorpes. Shallow Well. 1905.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ..	1,378·0	965·0	1,233·0	861·0	1,890·0	1,323·0
Temporary hardness ...	40·0	28·0	60·0	42·0	280·0	19·6
Chlorine.. ...	690·0	483·0	549·0	384·2	384·2	619·2
Equivalent as sodium chloride ..	1,136·8	796·0	905·0	633·0	1,458·0	1,021·0
Oxygen absorbed	..	...	...	...	...	...

	Spring at Osbornes. 1906.		Well at Grove. 1894.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	384·0	26·10	1,411·6	988·0
Temporary hardness ...	26·0	19·6	...	...
Chlorine	184·0	128·8	738·1	516·7
Equivalent as sodium chloride	303·0	212·0	1,261·5	851·6
Oxygen absorbed	...	...	...	...

	Well at Cassada Garden. 1894.		Well at Ferris Farm. 1911.		Liberta Old Well. 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	541·3	378·9	113·0	79·1	130·0	91·0
Temporary hardness ...	...	...	53·5	37·5	33·2	37 2
Chlorine... ...	237·0	163·9	29·0	20·3	11·2	28·8
Equivalent as sodium chloride ...	390·6	273·4	17·2	33·5	67·9	47·5
Oxygen absorbed			very	large	0·154	0·108

	Liberta New Well.	
	Parts per 100,000.	Grains per gallon.
Total solids	72·0	50·1
Temporary hardness ...	8·3	5·8
Chlorine	5·5	3·9
Equivalent as sodium chloride	9·1	6·4
Oxygen absorbed	1·266	0·886

The data cannot be regarded as nearly so complete as those given in the case of the limestone district. The samples from Gambles, Gunthorpes and Grove represent the water derived from those lands most highly impregnated with salt in the central plain. So far as the data available go these appear to form a narrow strip running across the island adjacent to the limestone outcrop. The waters from Osbornes Village and Cassada Garden are of interest as they are situated on the border between the limestone and central plain. Though distinctly salt in character they possess far less sodium chloride than do those derived from the more saline beds. Those from

Ferris Farm and Liberta represent the other side of the area approaching the junction with the southern volcanic district. Here it will be seen that the water is of much better quality, and it appears possible that the district either did not share in the general immersion, or, more probably as in the northern district, the lower lands were immersed to an increasingly shallow depth as one proceeds south, and that the water drained off early, possibly with the formation of local salt pockets such as are characteristic of the limestone area.

The sample from the new well at Liberta differs markedly from the remaining samples. From the result and from local circumstances it appears highly probable that the well is not deep enough to reach the true water table and that the water derived from it is only surface drainage in reality.

Regarding St. John's itself, the following data concerning the salt in wells in the town are reproduced from Dr. Watts's memorandum :—

	Well at Cross Street and Nevis Street.		Well at Nevis Street and Temple Street.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Chlorine	66·5	40·5	144·7	101·3
Equivalent as sodium chloride	109·6	76·7	238·5	167·0

	Redcliffe Street and Corn Alley.		Long Street and Thames Street.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Chlorine	221·9	155·4	177·0	81·9
Equivalent as sodium chloride	365·7	256·0	192·8	135·0

	Corn Alley and Newgate Street.		North Street and Wilkinson Street.		St. Georges Street.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Chlorine	156·0	109·2	224·5	157·2	449·9	315·0
Equivalent as sodium chloride	257·1	180·0	370·0	259·0	741·4	519·0

The samples roughly represent a line drawn diagonally across the town from S.E. to N.W. and it will be seen that as the wells approach the N.W. extreme and near the saline deposits, the salt content of the waters increases.

The southern district of the island is underlain by volcanic masses which have penetrated the overlying sedimentary beds, and folded and altered there to a greater extent. In consequence the country is much convoluted and consists of a series of rugged hills and valleys with a main substratum of impervious volcanic rock, covered with soils and subsoils derived from them, and varying in texture from light sandy soils to heavy clays. These naturally tend to accumulate in the bottom of the valleys by washing, and with such a set of conditions, a good deal of underground seepage water will be found in many places.

The character of these waters is illustrated by the following series of analyses :—

	Jennings Well.		Blubber Valley Well.		Claremont Spring.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids ...	152·0	106·4	76·0	53·2	88·0	61·6
Temporary hardness	63·0	44·1	45·4	31·8	54·6	38·2
Chlorine ...	28·4	19·9	13·6	9·5	15·0	10·5
Equivalent as sodium chloride ...	46·8	32·8	22·4	15·7	24·7	17·3
Oxygen absorbed	·301	·211	·289	·202	·173	·121

	Frys Well.		Joe Merry Spring. December 1911.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	180·0	126·0	94·0	65·8
Temporary hardness ...	40·0	28·0	20·9	14·6
Chlorine	38·0	26·6	34·4	24·1
Equivalent as sodium chloride	62·6	43·8	48·4	33·9
Oxygen absorbed ..	·499	·349	0·259	0·181

	Johnsons Point Well.		Crabb Hill Well.	
	Parts per 100,000.	Grains per gallon.	Parts per 100,000.	Grains per gallon.
Total solids	738·0	516·6	340·0	238·0
Temporary hardness ...	43·9	30·7	41·8	29·2
Chlorine	316·5	221·6	153·7	107·6
Equivalent as sodium chloride	521·6	365·2	253·3	177·6
Oxygen absorbed	·365	·255	·398	·279

Judged by the first five samples, which may probably be regarded fairly typical of the underground waters of this area, the waters are of a fairly satisfactory character. When wells are sunk on low-lying land close to the sea, they are liable to be salt owing to the diffusion of sea-water into the soil, or to the existence of the raised beds of old salt marshes. This state of affairs is represented in the case of the two samples from Johnsons Point and Crabb Hill.

The reserves of underground water in this area do not probably approach in magnitude those of the limestone area, which owing to the pervious nature of the rock are able to retain large quantities of water. There appears, however, reason to believe that a sufficient supply of underground see-

page water will be found in the deposits at the bottom of many of the valleys to be capable of being drawn on to meet local requirements at many points.

In the foregoing the attempt has been made to make a general survey of the sources of water-supply of Antigua. The attempt leaves much to be desired in many directions. At the same time the collection of this information into concise form enables a clearer grasp to be obtained of the position.

In collecting the data, recourse has been made to the analyses accumulated in the records of the Government Laboratory during the past thirty-one years; to supplement this a large number of additional samples have been taken and the waters analyzed for the purpose of this investigation. For the performance of much of the analytical work in this connexion Mr. V. M. Weil, Assistant Chemist, is responsible; while thanks are also due to Hon. R. A. L. Warneford, Chairman of the Country Board of Health, for the co-operation of the Board in taking many of the samples through the medium of the Clerk, Mr. J. S. Watt.

APPENDIX.

UNDERGROUND WATER-SUPPLY IN ANTIGUA.

There are in Antigua three districts in each of which the question of the underground water presents distinct features: viz., (1) the limestone district of the north and east, extending from Weatherills Point to Willoughby Bay, (2) the central plain lying to the south and west of (1) extending from St. John's to Willoughby Bay; and (3) the broken country lying to the south and west of a line drawn from Goat Hill to English Harbour.

(1) THE LIMESTONE DISTRICT. It is probable that water will be found almost anywhere in this district, but as the rocks have a general tendency to dip towards the north-east and as the water-supply depends upon the rainfall within the district itself, it is likely that the supply will be more abundant at a distance from the line separating this district from (2) the central plain, and wells would preferably be placed to the north or east of slopes. I think water would be obtained in almost any of the lower lands in the district lying to the north-east of a line drawn from, say, Weatherills to St. George's Church (Popeshead district). I believe there is water on the eastern side of Blackman's Hill. It appears to me probable that water will be found in almost any part of the district lying east of a line drawn from Blackmans to St. Philip's Church (Parham and Windward districts). (See Admiralty Chart of Antigua.)

In this district, one may expect to find it necessary to dig down to sea-level before water is reached, and then, in order to tap the water-bearing strata, to sink the wells still lower, but in no case would this involve deep wells unless digging were unnecessarily commenced in elevated spots. By deep, wells I mean of over, say, 100 feet.

In the Popeshead district the water will be of excellent quality and free from salt, as is evidenced by the wells at Royals,

Thibous, Lathefield and the well or spring very near the sea at Crosbies. In the southern and eastern districts I anticipate that the water will be of good quality, free from salt; though here and there, certain *superficial* wells are brackish, wells of moderate depth in this district will, I believe, yield good water.

This limestone district (1) to my mind constitutes a natural water reservoir of importance to Antigua which should be drawn upon to supply the needs of the villages and estates situated within its limits, instead of relying upon outside supplies from such places as Wallings. It is even likely that this district should be able to contribute to the supply of other parts of the island.

(2) THE CENTRAL PLAIN. This constitutes a low-lying district between St. John's and Willoughby Bay.

During recent geological time the island was submerged some 50 feet or so below its present level and a narrow belt of the sea ran from where St. John's Harbour is to Willoughby Bay. The elevation of the land has left this district impregnated with salt, so that while there is water in the works underlying the valley, it is, in almost every instance, too salt to be of use. It is just possible that water free from salt might be obtained if wells were sunk along the southern and western border of this district in such places as Belmont, Belle Vue, All Saints, Tyrrells and Piccadilly, where the land was, perhaps, not submerged. I am not aware of wells of moderate depth in this so-called border.

(3) THE BROKEN COUNTRY OF THE SOUTH-WEST. This, being the hilly or mountainous part of the island, constitutes the district where surface water and streams are of some small importance. It is this district from which, at present, the island's water-supply is derived. The water for the public supply of St. John's is derived in part from shallow springs in the neighbourhood of Mill Hill and Wallings, and in part from the stream at Body Ponds. Wallings reservoir has been built to collect surface water, draining from the hills, for the supply of cetain country districts. Along the northern limit of this district we have the Bendals stream, and in the south there is a stream flowing from Fig Tree Hill to Claremont.

All these are manifestations of surface water. Very little is known or can be predicted, about the underground water of this district on account of its irregular geological structure.

Contrary to what has been said by all previous writers on the geology of Antigua, who have described this as the oldest formation in the island, I find that it may be more properly regarded as the *newest*. It consists of a continuation of the beds to be found in the central plain, but these have been irregularly broken up, contorted and altered by the intrusion of extensive volcanic masses.

In such a jumble as here results, it is difficult to indicate what is occurring at any depth beneath the surface. Yet it seems very probable that water may be obtained by digging

wells into the alluvium occurring in the valleys and at the foot of the hill and, when obtained, the water will be good and free from salt.

With water available, as I believe it is in practically inexhaustible quantity in the limestone district (1), it has always appeared to me that a village or similar locality might be easily provided with an unfailing supply of water by digging a well and erecting in connexion with it a pump worked by a small aermotor, which would constantly pump water into one or more cisterns from which water may be drawn therefrom for use. This I think a preferable plan to having open wells from which water is drawn by a bucket which, apart from being dangerous, are liable to serious contamination, and preferable to causing the people to pump water by hand; for in this case there are endless and hourly quarrels for priority and constant breakings of the pump.

At present the wells in Antigua barely penetrate the water-bearing strata; for, from lack of appliances work has to cease as soon as any appreciable quantity of water flows into the well.

A powerful pump would enable the wells to be carried to a greater depth, and so considerably increase the water-supply.

I cannot pose as an expert and am hardly in a position to decide whether the digging of open wells by hand or the use of deep boring appliances is to be advised. If only shallow wells of under 100 feet are required, there will be little difficulty in digging them by hand. Boring apparatus would enable us to solve one or two problems. For example, the deeper waters of the central plain could be examined, when it would be ascertained whether they, like the more superficial, are contaminated with salt.

DOES THE SEREH DISEASE EXIST IN THE WEST INDIES, MORE ESPECIALLY IN TRINIDAD?

BY DR. F. A. F. C. WENT.

[In relation to some of the informal discussions (see *West Indian Bulletin*, Vol. XII, p. 205) that took place during the Agricultural Conference of 1912, one of these had reference to the possible existence of the sereh disease of sugar-cane in Trinidad. The interest that has been shown in the matter has led to the publication, under the above title, of the following paper by Dr. Went, which was received just previous to the holding of the Conference. It is succeeded by the report of a committee of the Trinidad Board of Agriculture, appointed in May to enquire into the subject, and by a memorandum by the Assistant Director of Agriculture, Trinidad, reporting the result of an earlier enquiry into the same matter.—Ed., *W. I. B.*]

As most sugar-cane growers probably know, a serious disease of the cane exists in the island of Java. Especially in the first years after its discovery, it spread over the greater part of the cane fields, causing serious damage. The loss was felt all the more keenly because it coincided with low sugar prices, making the years between 1883 and 1889 very critical for the cane sugar industry of Java.

The sugar planters however improved their position by energetically fighting the disease. Indeed, it might be argued that, after all, the sereh disease has been a blessing in disguise to the sugar industry of Java, since it was only the above-mentioned crisis which induced the planters to establish experiment stations in order to obtain the advice of scientific men, so that only since then the whole industry of Java has been carried out on a more and more scientific basis.

Up to the present, the real nature of the disease has not been discovered: but notwithstanding this, measures have become known by which an efficient struggle against the disease is possible, so that there no longer exists any fear among Java planters with regard to the sereh disease. These measures are very expensive, so that investigations are being carried out continually in order to find other remedies. But even if the disease did not exist, these measures would probably pay, as they have contributed in no small degree to augment the tonnage per acre of the Java sugar industry.

There is a common belief that the sereh disease is limited to the East Indian Archipelago and perhaps also exists in Queensland. An investigation by Kobus, made several years ago, showed that it did not exist in British India. Ten years ago, I myself visited tropical America; I searched very carefully for the sereh disease in Surinam, but could not find it there, nor did a more superficial investigation of cane fields in British Guiana, Trinidad, Barbados and St. Martin show me any symptoms of the disease.

But a few months ago, Dr. Lewis H. Gough sent me pieces of canes cut out of diseased cane stems grown in the island of

Trinidad, asking me whether it could possibly be sereh. Although the internal symptoms all pointed very clearly to the conclusion that the much dreaded disease might indeed be present, yet there were reasons, to be mentioned hereafter, why I did not dare to give an affirmative answer to the question propounded to me. After studying living canes sent by Dr. Gough, and after examining other preserved material collected by him, I could not form a more definite opinion.

The question whether or not sereh is showing itself in the West Indies, more especially in Trinidad, is of prime importance to the sugar planters in that region. This is the reason why, in consultation with Dr. Gough, I have written the present article, in order to draw the attention of planters to the matter.

As there are no good descriptions of the disease in the English language, I will begin by giving an account of the symptoms of sereh in as brief a form as possible.

Sugar-cane attacked by the sereh disease may show the symptoms in very different degrees, so that for the description several stages of the illness can be distinguished. In the worst stage there are almost no upright stems to be seen, the internodes remaining very short, so that the leaves having their points of insertion very near to one another, together get the appearance of a fan. The number of stems is very considerable as most of the buds sprout: in this way the whole plant makes the impression of a grass, known in Java under the name of 'sereh' (in English—lemon grass, *Andropogon Schoenanthus*, L.). On removing the leaf sheaths a network of roots enclosing the stem becomes visible; this in consequence of many of the adventitious roots developing.

In a less serious stage of the disease, normal upright stems are produced, but here also many buds sprout, forming short shoots in the same way as with canes attacked by top-borer; also a great many of the roots develop in the same manner, as mentioned before.

In a still less serious degree of the disease, hardly any outward signs indicate that the canes have been attacked; but the short joints at the top of the stems are characteristic, though these may also be found in healthy canes. The only remaining symptoms, which are always present, are the red-coloured fibro-vascular bundles; these may easily be discovered on splitting the stems longitudinally. The nodes more especially show a great many of these discoloured vascular bundles, which on microscopical inspection appear to be gummy, thus presenting the appearance always offered by a stem of the sugar-cane, wherever a part of it has been damaged, the vascular bundles communicating with the damaged spot being gummy and red-coloured. But in this instance the diseased vascular bundles are more especially to be found among those, which enter the stem from the leaf sheaths, so that the red colour may be detected thence over a longer or shorter distance to the base of the stem.

The disease is cumulative in this respect, that cuttings from sound canes may give canes showing only the

less serious stages of the disease, whereas cuttings from these diseased stems become badly attacked and the third generation may even be attacked in such a way that a whole cane field looks like a plantation of lemon grass with here and there a cane stalk arising out of the low grass-like clusters. Ratoon fields almost invariably are badly attacked.

As was stated above, the cause of the disease has not yet been discovered ; there is even a controversy about the question of the contagiousness of sereh. Most investigators, and among them the writer of the present notice, believe that the way in which the disease did spread over Java is a very strong indication of its being infectious. But others, for instance Wakker, insist that no direct proof has been given for this contagiousness ; they think that it ought to be explained by a deterioration of the cane.

We can leave this question where it stands, asking for the way in which the repression of the disease has been carried out in Java. In the first place, extreme care has been taken to use only cuttings from perfectly sound canes ; in order to obtain these, plantations of canes have been made in the hill districts at a height of about 2,000 feet. The climate there is very wet—at least the rainfall is much more considerable than lower down in the plains of Java. When these canes reach an age of about six months, they are cut and the whole stem is divided into cuttings. The cane plantations in the lower plains which have to produce canes for the mills are planted with these cuttings ; from them a second and even a third generation may be planted without getting so much sereh that it is seriously detrimental to the product.

Another manner of checking the sereh exists in cultivating varieties of cane which are able to resist an attack of the disease. In the first instance varieties from other countries were imported, among these Louzier, Manila and Hawaii canes, but most of these have not been able to withstand the attack for many years. Afterwards, seedling canes have been used ; although the expectation has not been realized that seedlings would always be immune to the sereh disease, yet several new seedlings have been obtained, which were resistant in a sufficient degree.

Dr. Gough wrote to me that the canes affected are Bourbon canes and that no other canes get this disease in Trinidad. The first statement would correspond with the fact that also the original yellow Java cane can be badly affected, which cane probably is indentical with the Bourbon cane.

I will give the description of the disease in Dr. Gough's own words : 'I have observed the following symptoms. (1) The only common symptom of the disease present in all the canes examined, has been the reddening of some of the fibro-vascular bundles, which on examination prove to be filled with gum. Such fibro-vascular bundles can be traced in some cases through more than one internode. They are most distinct in the nodes, where by careful examination it is possible to follow them for 2 cm. from their point of insertion in the leaf sheath, through the node and into the internode. Conical sections through the base of the node give the same appearance

as on Plate XI, Fig. 3, of your (i.e. the writer's) monograph. The diseased fibro-vascular bundles occur in the root stock—often connecting with similar ones in the mother plant and in the cane up to the apex. The reddening does not spread anywhere to the other tissues, which usually appear to be more or less normal. (2) The rootlets in very many cases were for the greater part dead; in some cases I estimate that fully 90 per cent. were dead. (3) The buds on such diseased canes were *all* either swollen, or had started growth, especially near the base, though sometimes the young shoots were found to be dead after having grown for about 10 cm. The resting rootlets at the nodes of some of the canes had also started, sometimes at a distance of 4 feet from the ground, where there was no evidence to show that they had been protected by trash. (4) Although the present crop season has been very dry, and the canes are just ripe, a very plentiful supply of young shoots has started growing up from the underground. (5) The leaves are found to be dying off, occasionally along the midrib first, more frequently however in longitudinal stripes or along the margins and from the tip, or one side of the leaf is dead and the other side still green. (6) Shortening of the joints was not very pronounced. At the apex of the cane the joints are normally short, so no notice can be taken of their being so there in this case.'

Dr. Gough thinks that insect injury, Marasmius (root disease) or other fungi cannot be held responsible for the phenomena observed; pieces of cane cut out sterile with a hot knife uniformly gave negative results.

In a later communication, Dr. Gough states that he has seen canes diseased in the manner described above from five different estates in Trinidad; their description, is given and though the symptoms are not always the same, the red-coloured gumming vascular bundles in the internodes are always present. But it should be categorically mentioned that he did not see even once the characteristic outward signs of *badly* diseased canes; such was neither the case in the photographs he sent me.

Some living canes were sent to me from Trinidad, but unfortunately these showed hardly any symptoms of the red vascular bundles, so that they gave no solution to the question.

My opinion after a close inspection of all the material would be the following. If all these canes had come from Java I would not have hesitated for a moment and would have declared them to be attacked by sereh. But here we have canes from a country where hitherto this disease has never been detected, nor was this the case on the whole American Continent. It seems prudent, then, not to make too bold an assertion for the present, more especially as the more serious symptoms have not yet been detected in Trinidad. Hence, I should venture to say that the island of Trinidad is suspect in regard to sereh and that it will be well for planters to keep a keen lookout for any more serious signs of the disease as described above.

If the sereh disease has really attacked the Bourbon canes in the West Indies, measures will have to be taken to check it,

either by propagating plantations in the hill country or by using seedling canes. The West Indian islands and British Guiana have the good fortune that, already for a great many years, seedling canes have been raised there by Professor Harrison and by Mr. Bovell and other officers of the Imperial Department of Agriculture for the West Indies, so that a repression of the disease, if necessary, will not be too difficult a task.

[It has been thought well to append to the above signed statement by Dr. Went, dated December 1911, the following details of procedure that was taken subsequently in Trinidad. —Ed., *W.I.B.*]

MEMORANDUM BY MR. FREEMAN, DATED APRIL 10, 1912.

The Director of Agriculture.

With regard to Dr. Went's article on sereh disease I have the following observations to make. For convenience of reference I have numbered the paragraphs in his paper.

The question of the possible presence of sereh disease in Trinidad arose only, I think, in June 1911 when Dr. Gough showed me a letter he had received from Dr. Went. This letter we decided to regard as confidential, and I arranged an interview between His Excellency the Governor and Dr. Gough on the matter. The matter came up at the Board of Agriculture; see minutes of meetings of June 16 and July 21, 1911 (*Bulletin of the Department of Agriculture*, Trinidad, Vol. X, No. 69, pp. 244 and 246). A subsequent letter from Dr. Went, received through you, did not materially advance matters, and finally we have Dr. Went's present communication dated December 1911.

I visited Waterloo on February 3, this year, and in company with Messrs. J. R. Bovell, J. Black and J. J. Carlee examined the field showing the disease from which Dr. Gough obtained his specimens. It is new land, cleared about four years ago, the old stumps in many cases being still in the ground. The canes attacked are Bourbon. The worst stage of sereh described by Went (par. 8) was not seen.

The canes have something of the appearance described in par. 9, with the important exception, however, that the aërial roots do not develop.

The red colouration of the bundles described in par. 10 was seen, but this is not characteristic of sereh disease only, and Mr. Carlee considered that gumminess was not present to the degree to which it occurs in sereh as seen by him in Java.

The field examined was third ratoon canes and, as noted above, exhibited only the symptoms, and not all of those even, of a slight attack of sereh. Whereas in par. 11 it is stated that the disease is cumulative and ratoon fields are almost invariably badly attacked.

Dr. Went's conclusion therefore appears borne out by an examination in the field; that is to say, there is as yet no definite evidence that sereh is present in Trinidad—the more

serious symptoms not having been yet detected, even in ratoon canes.

At the same time it is a disease which requires careful watching, and it would be well to investigate it thoroughly. in order to ascertain if possible the cause. It might then be possible to prove definitely that it is not sereh, although resembling it in some external characters. This is, I think, important as even the suspicion of sereh is likely to cause considerable harm, especially abroad, because reports are so apt to be exaggerated, and an impression may easily get about that the Colony is suffering from sereh.

MEETING OF THE TRINIDAD BOARD OF AGRICULTURE SUGAR-CANE COMMITTEE.

A meeting of the Sugar-cane Committee, Board of Agriculture, held at the Usine St. Madeleine on May 23, 1912.

Present: Professor P. Carmody (Director of Agriculture) Messrs. H. E. Murray, J. Moodie, J. Arbuckle and McLeod, with Messrs. W. G. Freeman (Assistant Director of Agriculture), J. B. Rorer (Mycologist, Board of Agriculture), F. I. Morris and W. Carlee.

The Committee visited a field of canes (D. 625) which was one of those seen by Dr. Gough in 1910 and considered as possibly suffering from sereh disease. The canes are in a comparatively dry and exposed situation. When seen by Dr. Gough the only definite sign of sereh was red fibro-vascular bundles. At the time of examination by the Committee even this sign was not found. The canes, though one year older ratoons than when seen by Dr. Gough, showed no signs of the spread or increase in intensity of the disease, which would be expected had they been suffering from sereh. In fact, in the opinion of Mr. H. E. Murray, the Manager, the field was in better condition this year than last year, although the season had been more unfavourable to canes generally.

After careful examination, the Committee came to the conclusion that, so far as external and internal symptoms went, there was no indication that these canes were suffering from sereh disease. Two members of the Committee stated that they had seen canes presenting similar abnormal symptoms some fifteen years ago.

The Committee discussed Dr. Went's paper, Mr. Freeman's memorandum of April 10, and Dr. Watts's letter of April 19, and was unanimously of opinion that no evidence had been produced at present to indicate the presence of sereh disease in Trinidad, and, that until more definite evidence is forthcoming, it is not prepared to agree with Dr. Went's remark in par. 20 that 'the island of Trinidad is suspect in regard to sereh'.

More work is necessary to clear up the nature of the abnormal growths to which attention has been drawn. It is important to note, however, that canes affected do not show all the symptoms of even a mild attack of sereh, that the disease does not appear to be one which spreads or is contagious, the only character which connects it with sereh appears to have been the presence of red

fibro-vascular bundles noted by Dr. Gough, and in these the gumminess characteristic of sereh is lacking, even the red-coloured bundles are not now to be seen.

(Sgd.) P. CARMODY, Chairman.
H. E. MURRAY.
J. J. McLEOD.
JAMES W. ARBUCKLE.
JAMES BIRCH RORER.
W. G. FREEMAN.
JOHN MOODIE.

A REPORT ON OBSERVATIONS ON SCALE INSECTS.

BY H. A. BALLOU, M.Sc.

In June 1910, a line of investigation was started by the Imperial Department of Agriculture having for its object the accumulation of regular observations on scale insects, from which might be obtained facts regarding the periodicity of reproduction and the seasonal or other occurrence of parasitic and predaceous insects and parasitic fungi.

The observations were to be made by the officers of the local departments of agriculture and any others who might be sufficiently interested, and recorded on blank forms, on which printed headings indicated the nature of the information desired.

The records were to include the name of the scales observed and the plants on which they occurred, and an indication as to the abundance of scale insect larvae, that is, young scale insects crawling about over the bark and leaves of the plant, whether many, few or none, with remarks on the presence and abundance of lady-birds, parasitic insects and parasitic fungi.

It was hoped that a series of observations recorded each month, taking the same species of insects on the same plant month after month, would yield the desired information.

This plan has been carried out and the work has now gone on for eighteen months. In the case of certain scale insects, the records of their occurrence on the same food plants are fairly regular and continuous at several localities.

Thus in Montserrat we have records of the purple scale (*Lepidosaphes beckii*) continuous for seventeen months on limes at Grove Station, at Harris's Station, at Elberton and at Olveston, except that in September 1910 and in March 1911 no records were submitted from Elberton. In addition, there are observations from Grove Station for this scale on shaddock from June 1910 to January 1911, and on the navel orange from June 1910 to May 1911, and at Harris's Station on the orange from June 1910 to April 1911.

In Dominica the observations on this scale at four stations have covered the following periods: Botanic Station, eighteen months (July 1910 to October 1911); Agricultural School the same, except that in October 1910 no observations were recorded; at Sherwood fourteen months (July 1910 to August 1911) with no records for April and July 1911; at Hampstead the entire time covered by the record was seventeen months, but there were eight months in which no observations were received. Observations have been made upon other species of scales in the same manner at these and other stations. The species upon which the greatest number of reports have been received are:—

The purple scale (*Lepidosaphes beckii*), the orange snow scale (*Chionapis citri*) the green scale (*Coccus viridis*), the black scale (*Saissetia nigra*) and the oleander scale (*S. oleae*).

If the recorded observations for any given species are studied with regard to increase or decrease in the numbers of larvae on different host plants growing near enough together so that the climatic conditions are the same for all, a slight correlation may be traced; for instance, at Grove Station, Montserrat, the purple scale was under observation on lime, shaddock and orange trees.

On limes, the scale larvae were recorded as many in June, and as few in July, August, and September, and as none in October, November and December, increasing to few in January. On shaddock, as many from June to October, and few in November and very few in December and January, while on the oranges they were recorded as many in January, very few in February and none in March. The decrease in numbers is thus shown to occur in limes from September to October, and on shaddock and orange from October to December. At Harris's Station, the decrease from few to none came from November to December, and on orange from October to November, followed by slight increase during the period from December to February.

In Montserrat, it may be stated, there was a decrease in the numbers of larvae of the purple scale some time in the period from September to December, with one exception. In Dominica, there was also a period of decrease, but in this case it came later in the season, between November and February. The periods of increase in numbers of the purple scale appear to lie between November and April in Montserrat, and between November and May in Dominica. According to these statements the records would seem in a general way to confirm the general belief that the dry season is favourable to an increase of scale insects, while the wet season is unfavourable. The records in regard to the parasites are such that no statement can be made further than that the dry weather appears to be favourable to an increase of the insect parasites and lady-birds, and the wet season to an increase in the fungus parasites.

The records in regard to the orange snow scale *Chionaspis citri*), the green scale (*Coccus viridis*), the black scale (*Saissetia oleae*), and the mealy shield scale (*Pulvinaria pyriformis*) do not yet afford a sufficient amount of information to allow any statement being made with regard to them.

The records are not yet sufficiently complete for any conclusions to be drawn. The reproduction of scale insects appears to be almost continuous throughout the year, with variations in the rate of increase at certain times. There are indications, however, that interesting and useful information will be derived from a continuance of these observations, with certain modifications which are suggested by the experience already gained. The work as already carried out is of value as indicating the species of scale insects which are of importance in each of the islands and of sufficient abundance to be likely to provide opportunities for continuous records throughout the year, and those which may be omitted from future observations as yielding only fragmentary records. The experience gained by the observers will be useful in continuing the work, and ought to enable them to accumulate even more valuable records than in the past.

In carrying on this work of observation and record it is planned to endeavour to get observations on the abundance of the larvae of scale insects, and on the occurrence of their natural enemies. A limited number of species will be selected as most suitable for the purpose, and an effort made to obtain regular, definite notes on each species always on the same tree or plant, or at least on a definite group of trees or plants at each station, if possible. It is important that this be done in order that a continuous chain of observation may be recorded. The final results of these observations should be of value as an aid in following the development of these pests, in order that recommendations for the use of insecticides and of natural enemies may be made. A definite knowledge of the season when the scale insect larvae are most abundant, and of the conditions which favour such abundance, will be of value in spraying, and may result in a better knowledge of how to use natural enemies under control.

The thanks of the Department are due to the agricultural officers in the several islands for the trouble they have taken in making the obervations, and this applies also to those planters who have assisted in the same manner. The work in this connexion at the Head Office has been that of receiving and tabulating the observations.

THE COCOA-NUT INDUSTRY IN ANTIGUA.

BY H. A. TEMPANY, B.Sc., F.I.C., F.C.S.,

Superintendent of Agriculture for the Leeward Islands,

AND T. JACKSON,

Curator of the Botanic Station, Antigua.

As far as information of a definite character can be gathered, in connexion with the growing of this palm in Antigua, it would appear that no large areas were planted pravious to 1906-7.

At the present time, there are between 150 and 200 acres under this crop, and the nurseries attached to the Agricultural Department contain sufficient nuts to plant about 50 more. It may be interesting to state that the majority of the trees for this area were obtained from the same source: between 7,000 and 8,000 were raised and distributed during the last four to five years.

The young plantation now in the island possesses particularly sandy soil; in point of fact there are plain indications that the lands were inundated at no very remote period. These ancient sea-shores, for they are nothing more or less, possess subterranean water—the drainage from adjacent hills—and should prove good sites for the crop in question. As would be inferred, with such a soil as this, the young plants, for the first three or four years of their existence, suffer severely from lack of moisture. Afterwards, however, they make rapid growth, throw off the etiolated appearance possessed by them during their younger stages, and take on a dark-green, healthy colour.

The time when rapid growth takes place probably dates from when their roots tap the subterranean water-supply.

Previous to this the attacks of scale insects, especially that of *Aspidiotus destructor*, are somewhat serious. Afterwards however, the trees appear to be able to combat the ravages of this pest, for the older ones are particularly healthy.

Another drawback, which arises from the lack of organic matter in such a soil, is the irregularity with which the plants grow. Some commence growth immediately after planting, whereas the development of others is retarded. This is partly because of constitutional vigour possessed by certain individual plants, but probably it is more a question of some being planted in spots possessing manurial constituents that are lacking in others. On the whole, the experience of the last four years, two of which were extremely deficient in rainfall, would seem to point out that a fair measure of success can be looked for in the future, and that the growing of this crop may add one more minor industry to the meagre number possessed by this island.

The industry is of such very recent introduction that few conclusions can be drawn in lessons learnt from it at present. One point is however very self-evident, namely the necessity of giving young plants fairly generous treatment in the way of

manuring, when they are planted in a soil of a nature similar to that existing in the cocoa-nut plantations of Antigua.

It is extremely difficult to say what will happen in the future as regards the crop, but with careful fostering, the area planted in Antigua should reach, in the next few years, 500 acres. A much larger area of suitable land exists : valleys now in bush, possessing deep soil could be utilized, as well as some of that which forms gentle slopes to the sea. At a rough estimate, one could place the area of land in the island suitable for cocoa-nuts at between 1,000 and 1,500 acres.

MANURIAL EXPERIMENTS WITH THE GOVERNOR BANANA IN TRINIDAD.

BY J. DE VERTEUIL, F.C.S.,

Assistant Government Analyst, Trinidad.

Manurial experiments were started on the Governor Banana cultivation at St. Augustine estate in May 1910. The plants in the field selected were of good and uniform growth and had not yet started to throw out their first fruit bunches.

Each plot contained fifty stools and occupied an area of 135 feet long by 22 feet wide, or 2,970 square feet. Plots 2 and 9, 3 and 10, 4 and 11. 5 and 12, 6 and 13, 7 and 14, 8 and 15 have respectively been treated with the same artificial manures, but plots 2 to 8 have in addition received a dressing of pen manure.

The pen manure was applied to plots 1 to 8 on May 7, 1910, at the rate of 20 tons per acre, and its cost has been calculated at $1·20 (5s.) a ton. The artificial manures were applied on June 17, 1910. The manures were spread around each stool and the soil lightly forked up.

The plots were free of disease at the time of applying the manures, but in January 1911 disease made its first appearance. As soon as any plants showed signs of disease they were dug out, removed from the plot and 1 lb. of lime spread over the hole.

The table below gives the kind and quantity of manures applied, the cost of applying, the number and weight of buches reaped and the number of diseased stools dug out to October 31, 1911.

It has been found that the Governor bananas sell at an average net price of $16·00 * per ton, and this figure has been taken as a basis for calculating the value of the crops reaped.

* Mean price realized from sale of Governor bananas shipped from St. Augustine Estate from April 1, 1909 to September 30, 1911.

Mark on plot.	Manures applied. Kind.	Rate per acre.	Amount per plot.	Cost of manuring per plot.	Number of bunches per plot.	Weight of bunches per plot.	Value of crop per plot.	Net value per plot.*	Net value per acre.*	Diseased stools dug out.
				$. c.		lb.	$ c.	$ c.	$. c.	
1	Pen manure ...	20 tons	3,050	1 73	72	2,271	16 22	14 49	212 52	
2	Pen manure ... Sulphate of ammonia .. Sulphate of potash .. Bone meal ...	20 tons 200 lb. 200 „ 100 „	3,050 13¾ 13¾ 27¼	2 87	78	2,399	17 13	14 26	209 15	
3	Pen manure ... Nitrate of soda Sulphate of potash .. Basic slag	20 tons 200 lb. 200 „ 100 „	3,050 13¾ 13¾ 27¼	3 63	73	2,284	16 31	13 68	200 64	1
4	Pen manure .. Sulphate of ammonia .. Sulphate of potash . Superphosphate of lime ...	20 tons 250 lb. 200 „ 450 „	3,050 17 13¾ 30½	2 97	67	2,044	14 60	11 63	170 57	
5	Pen manure .. Nitrate of soda Kainit ... ... Superphosphate of lime ...	20 tons 200 lb. 400 „ 400 „	3,050 13¾ 27¼ 27¼	2 75	70	2,105	15 03	12 28	180 11	
6	Pen manure .. Nitrate of soda Chloride of potash ... Superphosphate of lime ...	20 tons 200 lb. 200 „ 400 „	3,050 13¾ 13¾ 27¼	2 83	69	1,816	12 97	10 14	148 72	1
7	Pen manure ... Calcium cyanamide ...	20 tons 300 lb.	3,050 20½	2 38	68	2,048	14 63	12 25	179 67	1
8	Pen manure ... Calcium nitrate	20 tons 300 lb.	3,050 20½	2 23	71	2,021	14 43	12 20	178 93	

* Cultivation expenses not deducted.

Mark on plot.	Manures applied. Kind.	Rate per acre.	Amount per plot.	Cost of manuring per plot.	Number of bunches per plot.	Weight of bunches per plot.	Value of crops per plot.	Net value per plot.*	Net value per acre.*	Diseased stools
			lb.	$ c.		lb.	$ c.	$ c.	$ c.	
9	Sulphate of ammonia ... Sulphate of potash ... Bone meal ...	200 lb. 200 „ 400 „	13¾ 13¾ 27¼	1 14	61	1,638	11 70	10 56	154 88	
10	Nitrate of soda Sulphate of potash ... Basic slag ...	200 „ 200 „ 400 „	13¾ 13¾ 27¼	90	48	1,255	8 96	8 06	118 21	1
11	Sulphate of ammonia ... Sulphate of potash ... Superphosphate of lime ...	250 „ 200 „ 450 „	17 13¾ 30½	1 24	54	1,420	10 14	8 90	130 53	2
12	Nitrate of soda Kainit .. ... Superphosphate of lime ...	200 „ 400 „ 400 „	13¾ 27¼ 27¼	1 02	47	1.276	9 11	8 09	118 65	15
13	Nitrate of soda Chloride of potash ... Superphosphate of lime ...	200 „ 200 „ 400 „	13¾ 13¾ 27¼	1 10	59	1,445	10 32	9 22	135 23	4
14	Calcium cyanamide ...	300 „	20½	65	65	1,917	13 69	13 04	191 25	16
15	Calcium nitrate	300 „	20½	50	34	899	6 42	5 92	86 82	20
16	Lime	10 cwt.	76¼	29	48	1,276	9 11	8 82	129 36	10

* Cultivation expenses not deducted.

It will be observed from the above table that all the plots treated with pen manure have given better results than the equivalent plots without pen manure.

The soils on the St. Augustine estate are deficient in organic matter, and it would appear that an application of pen manure at the rate of 20 tons per acre is essential for the profitable growth of bananas. The raising of stock in conjunction with banana cultivation is therefore very desirable, if not absolutely necessary.

A characteristic feature of the experiments is the fact that there were only three diseased stools in the plots treated with pen manure, as against sixty-eight stools where no pen manure was applied.

The net value per acre, after deducting the cost of manuring, is recorded in the table above, for future reference. But it is not advisable to draw conclusions from the experiments until results have been obtained covering a period of several years.

ARTIFICIAL CROSS-FERTILIZATION OF THE MANGO.

BY A. J. BROOKS,

Assistant Agricultural Superintendent, St. Lucia.

This work, as carried on at Dominica, is at present in its initial stages, but some benefit might be derived by placing on record the work that has so far been accomplished in the attempt to raise improved varieties of mangoes from seed.

There are numerous seedling mango trees to be found in most of the West Indian islands, the fruit of many being quite valueless from a commercial point of view, whilst others possess certain meritorious qualities which allow them to be described as second or third class fruits. Of first class fruits grown directly from seed few only are known to exist, and these have usually originated from plantations which have been confined in a great measure to one variety.

This variation, or failing to breed true, in seedling mangoes is due to indiscriminate cross-fertilization such as obtains in localities where numbers of different varieties are grown in close proximity, and where no attempt is made to protect the flowers from promiscuous cross-fertilization.

It is now generally acknowledged that by securing fertilization of a plant of one variety with pollen from a plant of a different variety, through cross-pollination, we obtain a

variable race of which the individual plants may be expected to possess the inseparable characters of both parents in a varying degree.

The aim of this cross-fertilization was to combine the good qualities of two distinct varieties into a single variety, by securing a number of cross-fecundations between the two, and rearing plants from the seeds thus formed.

The first step in this direction was to make oneself intimately acquainted with the structure and functions of the flower. The flower of the mango, which is pale-yellow with a pinkish tinge, is very small, being only about 3 mm. in diameter. The flowers are borne on much-branched panicles and are very brittle; therefore great care and skill are necessary in their successful manipulation. There are five stamens, not all of which are fully developed and produce pollen.

In the variety chosen as the pollen parent in this instance, two of the five stamens produced pollen but only the pollen from the largest stamen proved to be fertile.

Ceylon No. 1—the variety chosen as the pollen parent—is of good appearance, a prolific bearer, and possesses excellent keeping qualities which should make it a valuable variety for shipping purposes, but it is of poor flavour. The variety chosen as the seed parent was the Julie. This variety is a free and regular bearer and possesses an excellent flavour—by some considered to be unsurpassed—but the fruit is too delicate to stand shipment.

In this particular case the main object sought was to endeavour to procure a variety bearing the keeping qualities of the pollen parent, combined with the excellent flavour of the seed parent.

Panicles bearing flowers of the pollen parent were enclosed in muslin bags. Before the flowers had time to open, to prevent foreign pollen becoming mixed with it, panicles of the seed parent were carefully selected in the most sheltered portions of the trees, and the number of flower buds on them reduced to about twenty. As soon as these were large enough to handle—this was usually found to be about one day previous to their opening naturally—they were opened and emasculated. In most cases the corolla was also cut away with a sharp pair of curved manicure scissors; this was found to give easier access to the stigma. Great skill and care were necessary in this operation, as the pedicels are extremely brittle and many flowers were lost in this way, some falling at once and others withering, no doubt because of injuries received during emasculation.

After emasculation, the panicles were at once enclosed in soft paper bags—1 ℔. sugar bags being used for the purpose—the mouths of which were previously dipped in water to allow them to be drawn tightly round the base of the panicles and tied tightly with raffia to prevent the ingress of insects.

The stigma became receptive very shortly after the natural opening of the flower. This receptive condition of the

stigma was indicated by its turning slightly darker than the style and appearing roughened on its surface ; this can only be seen with the assistance of a strong lens.

A few ripe anthers were then chosen from Ceylon No. 1 and gently crushed on a watch glass. The pollen was then transferred to the stigma by a small scalpel made by hammering out the small end of a pin. This method was chosen in preference to the use of a camel-hair brush, as the amount of pollen obtainable in the case of the mango is very small and would possibly be lost in the hairs of the brush.

When the stigma had been successfully covered with the pollen the paper bags were quickly replaced. These were allowed to remain for several days, until the ovary commenced to swell ; they were then removed and replaced by fine muslin bags. In all 145 flowers were operated upon as described. This extended over a period of two months.

On the ninth day from emasculation, the bags were removed in each case and the flowers examined. It was then found that the majority of them had been shed and only a total of twenty-four out of the 145 commenced to swell.

The swelling of the ovary is, I believe, commonly regarded as a sign that successful fertilization has taken place. In the present case, however, thirteen of these ovaries ceased to develop and finally withered after having doubled their normal size. This swelling was probably due to some irritation being caused by the growth of the pollen tubes.

Eleven fruits continued to develop, but unfortunately very strong winds set in and destroyed seven of the most promising when they were about half developed. With great care four fully developed fruits were obtained but only two were successfully germinated.

Complications due to polyembryony had been anticipated, but only a single seedling developed in each case.

Experiments are in progress, the results of which are hoped to further our knowledge in solving this problem of the polyembryony of the mango. In the absence of information to the contrary, it would have been assumed—had it been necessary—that the strongest of the seedlings was the 'normal', believing it to have been the result of the fertilization of the egg-cell.

The two plants obtained have been planted out and are making good growth. When they have developed sufficiently, steps will be taken to induce early fruiting so that this work can be carried on to its final issue.

RICE EXPERIMENTS IN BRITISH GUIANA.

BY

PROFESSOR J. B. HARRISON, C.M.G., M.A., F.I.C.,
Director,

F. A. STOCKDALE, M.A., F.L.S.,
Assistant Director and Government Botanist,

and

R. WARD,
Agricultural Superintendent,
Department of Science and Agriculture, British Guiana.

EXPERIMENTAL RESULTS.

The results of experiments with rice in British Guiana from 1903-1907 inclusive were presented before the seventh Agricultural Conference, held at Barbados in 1908, and were published in the *West Indian Bulletin*, Vol. IX, pp. 246-52.

In that paper, report was made on the comparative yields of the most promising of over 100 varieties of seed-paddy obtained from the United States, Ceylon, Java and India when grown against the Creole varieties at the Experimental Fields of the Botanic Gardens, Georgetown. The results of manurial experiments with various phosphatic manures were also given.

In the earlier series of experiments the area of the land available was restricted, and the amounts of seed paddy of the different varieties was small. In 1906, however, sufficient paddy of selected varieties was available for comparisons to be made with various forms of phosphatic manures on plots varying from $\frac{1}{30}$-acre to $\frac{1}{40}$-acre each, and the mean results of such trials were given on pages 248-9 of the *West Indian Bulletin*, Vol. IX. From these results, an attempt was made to get an idea of the probable errors that were likely to arise in experiments with rice. The results of the trials with phosphates may be summarized as follows:—

Phosphates used.	No. of trials.	Deviation from mean, per cent. Excess.	Deficit.	Probable error of mean, per cent.
Slag	8	24·2	37·0	4·0
Basic superphosphate	5	35·6	14·4	5·5
Superphosphate	3	6·9	8·4	2·4

Other varieties were grown in plots of less than $\frac{1}{60}$-acre in area and in these cases the results were as follows:—

Phosphates used.	No. of trials.	Deviation from mean, per cent. Excess.	Deficit.	Probable error of mean, per cent.
Slag	3	29·8	28·2	7·6
Basic superphosphate	16	52·4	30·5	3·8
Superphosphase	17	22·7	38·6	2·0

From these results it was clear that the maximun errors of single plots (viz. 37 per cent. in the series of larger plots and 52·4 per cent. in the series of smaller plots) were far too high, and that owing to the wide range of variation, reliable conclusions could not be drawn as to the action of the manures.

In 1907 a series of eighteen duplicate comparisons were made on plots of $\frac{1}{50}$-acre. These showed on single plot results maximum deviations from the mean of the duplicate plot of 30·1 in excess and of 27·9 per cent. in deficit. The results also showed probable errors of about $\pm$ 13·7 per cent. from the mean of all comparisons if two plots were selected, of $\pm$ 10 per cent. with these plots, of $\pm$ 6 per cent. with six, of $\pm$ 5 per cent. with eight, of $\pm$ 4 per cent. with eleven, with a mean probable error of approxmately 1·5 per cent. if all the thirty-six plots were taken into consideration.

The range of possible errors from a few plots were more marked in the small plots than in the large ones. Plots of less than $\frac{1}{60}$-acre on relatively new land were found to be, with rice, far too small to give reliable results even when the experiments are carried out on many duplicated plots. Plots of $\frac{1}{50}$-acre are likewise too small unless a very large number of plo's are employed, while the range of variation with plots of $\frac{1}{20}$-acre and $\frac{1}{40}$-acre each indicates that even these areas were, under the special circumstances of the trials, not large enough.

In 1908 therefore, the experiments were re-arranged in the hope of reducing their liability to error. Only the most suitable rices, considering the needs of the Colony and of its rice industry, were retained, and the areas of the plots were increased to from $\frac{1}{15}$-acre to $\frac{1}{4}$-acre each, and each trial was repeated on at last three plots. The yields, in bags of 120lb., of paddy of the principal varieties cultivated in these experiments, have been as follows :-

	Paddy yields per acre. Bags of 120 lb.				Mean.
	1908	1909.	1910.	1911.	1908-11.
No. 3	40·1	42·4	44·2	27·1	38·4
No. 6	33·8	35·8	42·1	32·1	35·9
No. 75 (Suthrà dhán) ...	38·4	39·2	41·1	30·5	37·3
Creole	32·9	34·5	37·7	22·6	32·6
No. 18	27·0	30·9	35·4	28·0	30·4
No. 4	27·4	31·2	32·4	11·3	25·6
No. 17	24·7	26·7	29·8	26·8	27·0
Berbice Creole ...	—	20·9	—	22·1	21·5
No. 34	21·7	15·0	34·8	26·1	21·9
Carolina	16·0	19·2	36·2	—	23·8
Surinam Creole ...	—	—	27·8	26·5	27·1

The yields on twelve unmanured plots in 1908 and 1909, and on nine plots in 1910, give indications of the errors due to soil and other conditions which are beyond control. These show a maximum error of 7 per cent. in 1908, 8 per cent. in 1909 and 7·7 per cent. in 1910 on a single plot, with a probable error of 1·6 per cent. in 1908, 1·1 per cent. in 1909, and 2 per cent. in 1910 on the mean of the results of the whole of the plots. The average yields of the more promising varieties during 1908, 1909, and 1910, when compared with the Creole rices taken as 100, were as follows :—

	Yields, per cent., on that of Creole.
Creole	$100·0 \pm 1·8$
No. 6	$110·0 \pm 2·9$
No. 75 Suthrà dhán ...	$114·1 \pm 2·1$
No. 3	$117·8 \pm 2·1$

The mean yields of the various rices in 1911 were low, owing to an error in the irrigation of certain of the plots of the rices while they were growing, and through their becoming subsequently badly lodged by heavy rain-storms.

The yields of the best four varieties through a series of seven years (1905-11) may be of interest, although in the earlier years the experimental errors were larger than they have been since the re-arrangement of the experiments in 1908. These average yields are as follows :—

	Bags (120 lb.) of paddy per acre.	Creole taken as 100.
Creole ...	33 9	100·0 ± 2·4
No. 75 ..	36·1	106·4 ± 2 5
No. 6 ...	37·1	109·4 ± 2·6
No. 3 ...	37·6	110·9 ± 2·7

From these results it was evident that the three varieties Nos. 3, 6, and 75 could, from their yielding capacity, be confidently recommended for planting purposes in the Colony, and therefore it was considered necessary to obtain careful chemical and further milling tests of these and of some other varieties. The chemical analyses were made in the chemical division of the Department by the Assistant Analyst (Mr. J. Williams, F.C.S. aided by Mr. S. Man-Sonhing. The results were as follows :—

Variety.	No. 3.	No. 4.	No. 6.	No. 75.	Creole.	Berbice Creole.
Weight in lb. per bushel	48·5	50·5	51·0	50·2	49·0	55·0

Proximate Compositions.

Variety.	No. 3.	No. 4.	No. 6.	No. 75.	Creole.	Berbice Creole.
Water	13·2	11·7	12·1	13·1	13·6	12·0
Fats	2·2	2·8	2·8	2·3	2·2	2·4
Albuminoids* ..	4·2	4·3	3·5	3·8	4·2	4·4
Amides, etc.† ...	2·0	2·8	2·8	2·8	2·3	3·1
Saccharose	traces	traces	traces	traces	traces	traces
Glucose	·06	·06	·05	·05	·05	·05
'Gums'	2·6	2·7	2·2	2·2	2·5	2·3
Woody fibre	6·9	7·2	6·7	8·6	7·5	7·6
Digestible fibre, etc....	8·1	10·0	10·8	9·5	9·5	2·7
Starch	55·0	52·9	53·6	52·3	52·9	60·8
Mineral matters‡ ..	5·5	5·6	5·5	5·4	5·3	4·7
	100·06	100·06	100·05	100·05	100·05	100·05
*Nitrogen	·67	·68	·54	·60	·67	·70
†Nitrogen	·32	·45	·46	·44	·36	·49
Total nitrogen ...	·99	1·13	1·00	1·04	1·03	1·19
‡Insoluble matter ...	5·1	5·2	5·4	5·1	4·8	4·2
Silica ...	4·0	4·1	4·3	3·8	3·8	4·0
Soluble matter ...	·4	·4	·1	·3	·5	·5
Potash ...	·19	·20	·22	·18	·17	·14
Phosphoric anhydride	·64	·67	·59	·59	5·7	·62

From the preceding table it is evident that as regards composition the Berbice Creole is the best rice. It also appears that where there are fairly wide variations in the percentage of starch present in varieties of rice some guide to their value may be obtained from their relative weights per bushel. The determination of such weights should be an easily applicable method of ascertaining the relative quality of various kinds of rice. The milling tests were, as in former years, kindly undertaken for us by Messrs. Wieting & Richter and their report was as follows:—

'The yields of rice per cent. of paddy have been as follows:—

	Yield per cent. White rice.	Yield per cent. Brown rice.
No. 75	60·0	55·7
No. 6	80·0	46·8
No. 4	80·0	61·9
No. 3	72·5	45·8
Carolina Golden grain	60·0	67·5
Creole	72·5	42·7

Remarks:—

No. 75: It was very easily milled and would make a first-rate rice of either quality.

No. 6: Of a very good quality for both brown and white and is quite easily milled.

No. 3: Very good for white rice, but not so easily handled for brown, and the colour is very poor.

No. 4: No good for brown rice and gives a very poor white, the grain being very small and very hard to mill.

Carolina Golden grain (barley grain): No good for brown rice as it has a reddish colour, but will make a fairly good table white rice. It is very hard to mill.

Creole: The paddy is poor in quality and gave a very bad brown rice in colour and a bad return in white.'

From the above report it is evident that Nos. 75 and 6 were the best for brown rice. This report fully corroborated previous ones, and it has been decided to withdraw No. 4 entirely from cultivation, to limit the area planted under No. 3, and to extend as far as possible the cultivation of Nos. 6 and 75.

During the past four years, in addition to the above-described work, comparative trials have been made with more than 100 varieties of paddy imported from India, British Honduras, Java, Louisiana, Surinam, etc. Few of these proved to be suitable for cultivation under the conditions prevalent in British Guiana.

PURITY OF STRAIN.

In 1907, when a large number of varieties were grown in small plots, it was thought that a certain amount of cross-fertilization between the varieties had taken place, and this suspicion was confirmed in 1908. In that part of the Experimental Fields where varieties are grown for pure seed for distribution to rice growers it was decided only to plant the most promising varieties and take steps to get the strains as

pure as possible. The seed-paddy in 1909 was very carefully hand-picked before sowing and all 'rogues' were pulled out of the plots as they showed themselves. In 1910 this was again repeated, with the result that the purity of the rices had in two years been increased from 90 per cent. to 99 per cent. This procedure was adapted in 1911, and but very few 'rogues' had to be removed The purity of strain of the seed-paddy is of utmost importance from the miller's point of view, and the following figures are of interest from an agricultural point of view. In 1908 rice paddy was received from British Honduras. This was carefully picked over, and the apparent varieties separated. In 1909 five distinct strains were cultivated over fair-sized plots and a mean yield of 20·7 bags of paddy per acre was obtained. The yields of the different strains were as follows :—

	Bags (120 lb.) of paddy per acre.
Strain F	35·6
,, A	25·0
,, C	16·8
,, B	14·7
,, E	11·2

The strains were all separated from the one sample received and the above results furnish a striking instance of the necessity for planting selected pure seed-paddy if it is desired to obtain maximum crops.

Improvement of Varieties.

This experience led in 1909 to variants from the true type being selected for experimental purposes. Some 36 variants were chosen, the stools were bagged before the general flowering of the rice took place and the seed-paddy was kept separately. In 1910, these variants were very carefully tested and the selection of that year reduced the number of 1909 variants to twenty. These were planted in 1911 on variously sized plots (the sizes varied according to the quantity of seed-paddy available but were generally $\frac{1}{25}$-acre in extent) and seventeen that grew satisfactorily gave the following results :—

Kind of rice.	Yields of paddy. Bags (120 lb.) per acre.
No. 75—Variant No. 7	49·6
,, ,, ,, 6	48·3
,, ,, ,, 1	41·7
,, ,, ,, 5	40·8
,, ,, ,, 4	40·2
,, ,, ,, 2	23·3
,, ,, ,, 3	22·0
No. 6—Variant No. 1	41 9
,, ,, ,, 2	35 0
No. 3—Variant No. 1	39·6
Creole—Variant No. 1	40·0
Berbice Creole—Variant No. 2	35·6
,, ,, ,, ,, 5	28·1
,, ,, ,, ,, 3	27·1
,, ,, ,, ,, 8	25·0
,, ,, ,, ,, 6	23·1

The mean yields of the varieties from which these variants were selected were in 1911 as follows :—

No. 75	30·5
No. 6	32·1
No. 3	27·1
Creole	22·6
Berbice Creole	22·1

The better of these variants are being sown this year on areas of $\frac{1}{7}$- or $\frac{1}{15}$-acre each, and will be tested in comparison with varieties 6, 75, and Creole.

Similar variants selected in 1910 are under the same process of testing, and others were selected in 1911.

HYBRIDIZATION TRIALS.

In 1909 hybridization experiments were commenced and these have been continued throughout the season 1910 and 1911. Some hybrids have been obtained artificially and the segregation of several different characters are being observed. It is proposed to make experiments with crossing varieties 6 and 75 with the Berbice Creole with a view to improving the quality of the first-named heavy cropping varieties. The better of the selected variants will also be utilized for the improvement of the local strains.

RED-RICE.

'Red-rice' has been detected in some of the plots cultivated at the Experimental Fields and has not been uncommon in some samples of varieties 3 and 6. It is also very common in some of the principal rice-growing districts of the Colony and has of late been the cause of some complaints on the part of the purchasers of paddy.

Red-rice is so called from the red colour of the grains. In some cases the grain is a dark-red through its entire substance, while in other cases it is of a light-red shade. At times, when the rice is milled, the colouration appears as streaks of red where the glumes have been imperfectly removed. It is common in some districts in Louisiana. In that country it is kept under control by careful attention to the selection of pure seed stock, but in many parts of British Guiana where a second crop of rice frequently follows immediately upon the harvesting of the first crop, the eradication of red-rice is not a simple process. Careful cultural and botanical experiments are being conducted with red-rice at the Experimental Fields.

By the constant renewal of our stocks by single-head selection it is hoped to reduce the percentage of the red-rice in the standard varieties growing at the Experimental Fields to *nil* and the free distribution of large quanties of pure seed-paddy annually must result as has been the experience of Sralöf, Sweden, with wheat and other cereals, in a gradual improvement of the standard of British Guiana rice.

MANURIAL EXPERIMENTS.

Previous to 1908, the experiments with manures were designed to make comparative trials with various phosphatic substances,

but in that year the experiments were modified to include trials with sulphate of potash, and with lime. The results for 1908 and 1909 were as follows :—

	Yields bags (120 lb.) paddy per cent.			No manure, 100.	Probable soil errors per cent.		
	1908.	1909.	Mean.		1908.	1909.	Mean.
No manure	33·2	39·5	36·3	100	±1·8	±1·5	±1·6
No manure after phosphates 1905-7	36·1	39·4	37·7	103·8	±1·8	±1·5	+1·6
Sulphate of potash	37·6	38·3	37·9	104·4	±3·3	±2·7	±3·0
Sulphate of potash after phosphates in 1905-7	38·9	39·4	39·1	107·7	±3·3	±2·7	+3·0
Lime	39·5	39·8	39·6	109·1	+3·3	±2·7	+3·0
Lime after phosphates in 1905-7	38·8	39·7	39·2	107·9	±3·3	±2·7	±3·0

In 1908 increases were produced by the applications of sulphate of potash and of lime, but in 1909 no advantage was shown either from the manurings of the former years or from the applications of sulphate of potash to the crop. The mean results of the two years show that practically no increased yield was obtained by the applications of sulphate of potash, but small increases from the applications of lime were indicated.

A second series of experiments was laid out on part of a field that had not been so long under cultivation with rice as where the first series was carried out. The results were as follows :—

	Yield, bags (120 lb.) paddy, per cent.			No manure, 100.	Probable soil error, per cent.		
	1908.	1909.	Mean		1908.	1909.	Mean
No manure.	28·1	31·3	29·7	100	1·8	2·7	2·8
Sulphate of potash	29·5	32·3	30·9	104·0	3·3	2·7	3·0
Lime ...	31·4	...	...	111·7	3·3	...	...

These trials showed that no increases were obtained by the application of sulphate of potash, whilst some advantage accrued from the dressing with lime.

The results of 1908 and 1909, taken with those of earlier trials, indicated that on well-cultivated rice land, properly drained and satisfactorily irrigated with creek water, little advantage is likely to be gained by manuring with mineral manures, and in no case has any profit accrued from their application.

In 1910 and 1911 trials were made with sulphate of ammonia, superphosphate and sulphate of potash.

The results of all the trials in 1910 and of the non-manured plots in 1911 were as follows :—

	Yields, bags (120 lb.) paddy, per cent.		1910. No manure. 100.	
	1910.	1911.		
No manure ..	40·6	23·7	100	1·4
Sulphate of ammonia ...	40·6	failed	100	1·2
Sulphate of ammonia, sulphate of potash and superphosphate ...	41·4	„	101·9	1·7
Sulphate of potash and superphosphate ...	40·4	„	99·5	2·6

The results of 1910 indicated that increased yields were not obtained from the application of manures. It is possible that the land is too rich to profit by applications of manures; but there are indications that as the land becomes somewhat poorer, manurings with nitrogenous manures will prove advantageous.

In 1911 neglect in the control of the watering of the rices on the manured plots at a critical stage of their growth introduced such a considerable erorr-factor as to make the returns quite unreliable, both with reference to their mean yields and their relationship to non-manured plots. Whilst the probable error on the mean results of the not manured plots was ± 2·5 per cent. on those treated with sulphate of ammonia it rose to ± 5·2; on those manured with sulphate of potash and superphosphate it became ± 8·6; and on those which received sulphate of ammonia in addition to sulphate of potash and superphosphate, it amounted to ± 3·7 per cent.; whilst the range of deviation from the means of the various series of manured plots shown by single plot results was ± 43·3, ± 47 5, and ± 41·6 per cent., respectively. Both the probable error and the wide range of the deviations prove the unreliability of the results and the complete failure of the 1911 series of manurial experiments.

Distribution of Seed-paddy and Growth of the Industry.

The seed-paddy of the standard varieties is distributed gratis to rice growers through the principal millers. In 1909 the distribution from the Experimental Fields amounted to 4·7 tons, sufficient to plant 180 Rhynland* acres. In 1910 the amount distributed was 5 tons, in 1911, 6½ tons and in 1912 the amount to be sent out is 3 tons.

There is an increasing demand for the seed-paddy, as the growers are realizing that they obtain larger crops which command better prices than when they sow year after year from their own stock.

The areas under rice during the past four years have been as follows:—

	Areas, acres.
1908-9	37,854
1909-10	36,230
1910 11	31,680
1911-12	36,000

The average yields obtained throughout the whole Colony have been as shown in the following table in which the exports are also given:—

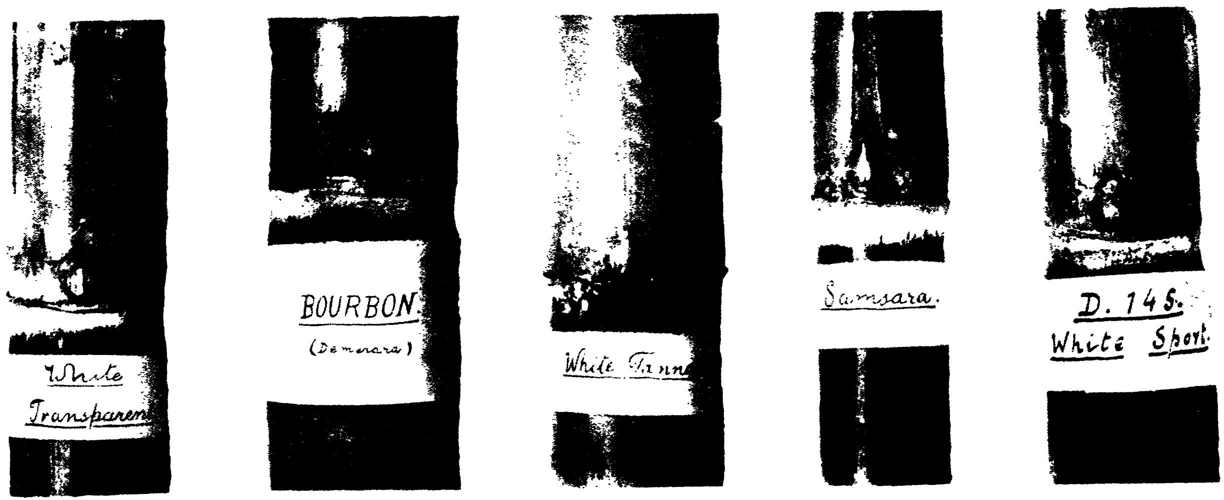
	Average yield of paddy per acre. Bags (120 lb. each).	Total produce in tons.		Export in tons.	
		Paddy	Rice.	Rice.	Rice meal.
1908-9	25·4	51,570	37,880	3,705·7	2,498
1909-10	22·1	43,000	31,600	5,488·7	1,911
1910-11	19·2	32,580	23,943	3,783·1	1,620
1911-12	20·8	40,093	29,464	2,989·6	1,361
Yearly average 1908-12		41,810	30,722	3,992	1,850

Value of Rice Industry.

	Value of rice consumed locally.	Value of exports.		Total Value.
		Rice.	Rice meal.	
	£	£	£	£
1908-9	382,750	50,060	4,870	437,680
1909-10	292,450	64,620	3,720	360,790
1910-11	225,800	50,600	3,160	279,560
1911-12	267,930	40,160	2,610	310,700
Yearly average 1908-12 ...	£292,230	£51,360	£3,390	£347,180

* A bag (of 120 lb.) of seed-paddy suffices to plant 2 Rhynland acres of rice-land, hence as a Rhynland acre is equal to 1·05 British acres, 56 lb. of seed-paddy will suffice to plant 1 acre. One Rhyndland acre will produce, say, 36 to 40 bags of seed-paddy. It will be readily seen how quickly the effect, of improved seed-paddy may be exerted over wide areas.

[Pages 399 to 580, issued September 18, 1912.]



VARIETIES OF CANE SHOWING TYPES OF EYE-BUDS.

(To illustrate the paper: The Study of Sugar-cane Varieties with a View to Their Classification; *West Indian Bulletin*, Vol. XII, p. 378.)

Imperial Department of Agriculture

FOR THE WEST INDIES

HEAD OFFICE—BARBADOS.

Imperial Commissioner of Agriculture for the West Indies	FRANCIS WATTS, C.M.G., D.Sc., F.I.C., F.C.S.

Scientific Staff.

Scientific Assistant	A. H. KIRBY, B.A. (Cantab.)
Entomologist	HENRY A. BALLOU, M.Sc.
Mycologist and Agricultural Lecturer	F. W. SOUTH, B.A. (Cantab.)
Veterinary Officer	P. T. SAUNDERS, M.R.C.V.S.

Clerical Staff.

Chief Clerk	ALLEYNE GRAHAM HOWELL
Assistant Clerk	MURRELL B. CONNELL.
Junior Clerk	WALWYN P. BOVELL.
Typist	MISS. B. ROBINSON.
Temporary Assistants ...	A. B. PRICE, Fell. Journ. Inst D. V. BARKER. L. A. CORBIN.

Messenger	E. E. LEACOCK.

List of Staffs of Colonial Establishments.

BARBADOS.

Department of Agriculture.

Superintendent of Agriculture	J. R. Bovell, I.S.O., F.L.S. F.C.S.
Assistant Superintendent ...	W. Nowell.

Sugar-cane Experiments.

Chemist-in-charge ...	Professor J. P. d'Albuquerque, M.A., F.I.C., F.C.S.
Agricultural Sup'dent ...	J. R. Bovell, I.S.O., F.L.S., F.C.S.
First Field Assistant ...	E. M. Peterkin.
Second Field Assistant ...	M. S. Goodman.
Lecturer in Agricultural Science	F. Hardy, B.A.

BRITISH GUIANA.

Department of Science and Agriculture.

Director and Government Analyst and Geologist	Prof. J. B. Harrison, C.M.G., M.A., F.I.C., F.G.S., F.C.S., F.G.S.A.
Assistant Director and Government Botanist	———

Head Office.

Clerk and Secretary, Board of Agriculture	E. S. Christiani.
Assistant Clerk, Artist and Librarian	Miss M. van Nooten.
Typist	Miss F. Goring.

Chemical Division.

Assistant Analyst	J. Williams, F.C.S.
Second Assistant Analyst..	K. D. Reid.
Laboratory Assistants ...	L. S. Davis. F. J. July.

Botanical Division.

Head Gardener	John F. Waby, F.L.S., F.R.H.S.
Assistant Gardener	Fitz Greeves.
Clerical Assistant	H. B. France.

Agricultural Division.

Agricultural Superintendent	R. Ward.
Agric. Instructors ...	A. L. Mansfield. W. E. Augustus. A. A. Abraham.
Agric. Assistants	W. H. Matthews R. L. Hunte. E. M. Morgan.

Educational.

Science Lecturer	A. Leechman, F.C.S.
Superintendent Onderneeming School and Farm	S. H. Bayley.
Supt. of Model Gardens ...	D. V. Jacobs.

Veterinary Division.

Veterinary Surgeon ...	J. A. Raleigh, V.S. Can., M.R.S.I. Eng.

Biological Division.

Economic Biologist ...	G. E. Bodkin, B.A. (Cantab.)
Clerical Assistant	L. D. Cleare.

TRINIDAD AND TOBAGO.

DEPARTMENT OF AGRICULTURE.

Director	PROF. P. CARMODY, F.I.C., F.C.S.
Assistant Director	W. G. FREEMAN, B.Sc., A.R.C.S., F.L.S.

Laboratory (Analytical).

Govt. Analyst	P. CARMODY, F.I.C., F.C.S.
Asst. Analysts	C. H. WRIGHT, B.A. (Cantab.) F.I.C., F.C.S. H. S. SHREWSBURY, F.I.C. J. DE VERTEUIL, F.C.S. A. E. COLLENS, F.C.S.

Educational.

Agricultural Science Master	C. H. WRIGHT, B.A., F.I.C., F.C.S.
Lecturer in Local Botany and Entomology	A. E. COLLENS, F.C.S.

Botanical.

Govt. Botanist and Supt. Royal Botanic Gardens	W. G. FREEMAN.
Asst. Superintendent and Curator R. B. Gardens	———
Curator, Botanic Station (Tobago)	W. E. BROADWAY

Stock Farms.

Manager, Govt. Farm (Trinidad.)	J. McINROY.
Manager, Govt. Farm (Tobago)	H. MEADEN.

St. Augustine Estate.

Manager	J. McINROY.

River Estate.

Manager	J. C. AUGUSTUS.

BOARD OF AGRICULTURE.

President	HIS EXCELLENCY THE GOVERNOR.
Vice-President	DIRECTOR, DEPARTMENT OF AGRICULTURE.

And 19 Members appointed by the Governor.

Staff.

Mycologist	JAMES BIRCH RORER, A.B., M.A.
Entomologist	F. W. URICH, F.E.S., C.M.Z.S
Assistant Entomologist ...	P. L. GUPPY, F.E.S.
Agricultural Inspectors ...	L. A. BRUNTON. D. C. PLUMMER.
Laboratory Assistant ...	H. CARACCIOLO (Jnr.)

List of Staffs of Colonial Establishments.—(*Continued.*)

GRENADA.

AGRICULTURAL DEPARTMENT.

Board.

Chairman (ex officio) ...	HON. EDWARD DRAYTON, C.M.G., Colonial Secretary.

One other official member and six members of the Agricultural and Commercial Society, appointed by the Governor.

Staff.

Superintendent of Agriculture ...	GILBERT AUCHINLECK, B.Sc., F.C.S.
Agricultural Instructor	GEORGE F. BRANCH.
Land Officer and Crown Lands Superintendent	WALTER BERTRAND.
Junior Assistant	L. J. BERTRAND.
Foreman, Botanic Station ...	J. C. CALLENDER.

ST. VINCENT.

Botanic and Agricultural Experiment Stations and Education.

Agricultural Sup'dent ...	W. N. SANDS.
Assistant Sup'dent ...	F. BIRKINSHAW.
Clerical Assistant ...	L. W. BROWNE.
Foreman	H. JOHN.
Assistant Master... ..	S. L. MOSELEY.
Veterinary Surgeon ...	C. P. STOUTE, D.V.S
Manager, Cotton Ginnery	S. B. ISAACS.

ST. LUCIA

Botanic and Agricultural Experiment Stations and Education.

Agricultural Sup'dent	J. C. MOORE.
Assistant Sup'dent	A. J. BROOKS.
Junr. Instr. and Overseer, Expt. Sta. ...	R. W. NILES.
Foreman, Bot. Stn.	M. A. LAWRENCE.
Copyist	N. RAWLINS.

LEEWARD ISLANDS.

Government Chemist and Supt. of Agriculture	HAROLD A. TEMPANY, B.Sc (Lond.), F.I.C., F.C.S.
Assistant Chemist ...	V. M. WEIL, B.Sc. (Lond.)
Junior Assistant	R. E. KELSICK.

DOMINICA.

Botanic and Agricultural Experiment Stations and Education.

Curator	JOSEPH JONES.
Assistant Curator ...	G. A. JONES.
Foreman	J. F. BAPTISTE.
Overseer	G. DE LACHEVOTIER.
Clerical Assistant ...	A. D. THORPE.

Agl. and Sci. Master ...	H. WATERLAND.

ANTIGUA.

Botanic and Agricultural Experiment Stations and Education.

Curator	THOMAS JACKSON.
Assistants for Agricultural Experiments	C. A. GOMES S. V. ATHILL.

List of Staffs of Colonial Establishments.—(*Concluded.*)

MONTSERRAT.

Botanic Station.

Curator	W. Robson.

ST. KITTS-NEVIS.

Botanic and Agricultural Experiment Stations and Education.

Agricultural Sup'dent ...	F. R. Shepherd.
Foreman	P. O. Webster.
Agricultural Instructor (Nevis)	W. I. Howell.
Agricultural and Science Master	W. R. Dunlop.

VIRGIN ISLANDS.

Agricultural Instructor...	W. C. Fishlock

BRITISH HONDURAS.

Botanic Station.

Curator	Eugene Campbell.

JAMAICA.

Department of Agriculture.

Director and Island Chemist ...	The Hon. H. H. Cousins, M.A. (Oxon.), F.C.S.
Supt. of Hope, Hill Parade and Castleton Gardens	William Harris, F.L.S.
Supt. of King's House Gardens	W. J. Thompson.
Clerk at Head Office	G. A. T. Stockhausen.
Librarian and Typist	Miss H. A. Wood.

Government Laboratory.

Deputy Island Chemist	R. Simmons, A.I.C.
Assistant Chemist	———
Junior Assistant	F. A. Thompson.

Agricultural Education and Experiments.

Bacteriologist and Fermentation Chemist	H. H. Scott, M.R.C.S., L.R.C.P.
Superintendent of Sugar-cane Experiments	Percival W. Murray
Sugar Chemist	R. S. Martinez.
Distiller	B. A. Thompson.
Lecturer in Agricultural Science	E. J. Wortley, F.C.S.
Instructor in Practical Agriculture	M. E. Taylor.
Head Master, Hope Industrial School	H. S. Palmer.
Agricultural Travelling Instructors	William Cradwick James Briscoe.
Secretary, Agricultural Society	**John Barclay**

INDEX

A.

B.

C.

D.

Diseases of Plants :—

E.

F.

G.

H.

I.

J.

R.

S.